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Cover Story

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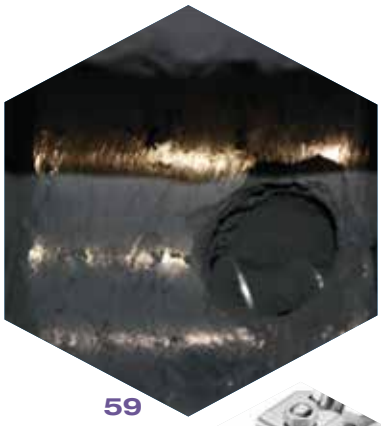
Technical and Practical



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CHEMICAL ENGINEERING
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Editor's Page

Weathering the crisis

In March of this year, the World Health Organization declared the Novel Coronavirus Disease, COVID-19, a pandemic. Now, six months later, we are still deep in the grips of this crisis as we experience its far-reaching effects and navigate how to move forward. The severity of the global situation demanded emergency responses from many sectors, including the chemical process industries (CPI). Now, attention is turning to longer-term strategies for navigating through the disruption, even while much uncertainty remains.

Economic outlook

Lockdowns throughout the world, necessitated by the pandemic, have led to a sudden and steep drop in global economic activity. Markets that are major consumers of CPI products, such as vehicles and housing, plummeted, while the increased need for chemical components used for disinfectants, personal protective equipment and medical-related instruments, may have somewhat offset the decline in the other market areas.

In its "Mid-Year Situation Outlook," published in late June, the American Chemistry Council (ACC; www.americanchemistry.com) projects that this year, the global GDP will contract 4.6%, and global industrial production will drop by 3.8%. The projections for the U.S. are somewhat more severe, with GDP dropping by 6.0%, consumer spending falling 6.4% and business investment dropping by 9.9%. The projections do, however, include potential rebounding in 2021. For example, Martha Moore, senior director of policy analysis and economics at ACC, projects that "Capital spending will fall 17.6% to $29.0 billion in 2020, then increase by 15.7% to $33.5 billion in 2021."

According to the report, data suggest that the global recession may have bottomed out. Kevin Swift, chief economist at ACC, says "After suffering the sharpest pullback on record in April, many industrial sectors are showing signs of recovery." At the time of this writing, the latest Chemical Activity Barometer (CAB; an economic indicator created by the ACC) in late July showed an increase, at which time Swift commented, "With three consecutive months of gains, the latest CAB reading is consistent with recovery in the U.S. economy."

Moving forward

As we look forward to economic recovery, still with much uncertainty, companies are evaluating strategies to move forward. One area that has been pushed into the spotlight is digitization. While the advantages of digitization and the need for adoption in order to remain competitive in a global economy had been recognized before the pandemic, the lockdowns and need for distancing during the pandemic suddenly accelerated this trend. This has been noted by management consulting firms. McKinsey & Company, for example, is looking at "how the acceleration of digitization during the COVID-19 pandemic is shaping the next normal," in its report "How six companies are using technology and data to transform themselves," (www.mckinsey.com; August 12, 2020).

And, in his keynote address at the AIChE Spring meeting last month, Bhavesh Patel, CEO of LyondellBasell, cited digitization as one of four key areas to shape the next decade of CPI operations ("Shaping the Next Decade: AIChE Virtual Keynote Highlights Digitization, Sustainability," www.chemengonline.com). The other areas he outlined were sustainability, globalization and plastic circularity. ■

Dorothy Lozowski, Editorial Director

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BPA

A new approach makes flexible screw pumps

Leistritz Pumpen GmbH (Nuremberg, Germany; www. leistritz.com) has recently introduced Flexcore, the first screw pump capable of adapting to a wide range of installation situations. "With Flexcore, Leistritz has now created a globally groundbreaking innovation — a pump class that, for the first time, unites qualitative, functional and economic aspects in an extremely flexible, quickly available series product," explains product manager Philipp Rossow.


Leistritz

"The cartridge unit of the Flexcore [cutaway diagram] is the heart of this pump," says Rossow. Since the bearing is positioned on the outside, it is independent of the pumped medium. Therefore, the Flexcore is especially suitable for low-viscosity media. The seal installation space is designed for all common DIN-K mechanical seals.

The split Flexcore casing consists of a suction and pressure part and can be rotated four times by 90 deg (photo). The


Leistritz

alignment of the optimum flange position makes the Flexcore extremely adaptable for installation — even in existing piping layouts. Depending on the application, different flange designs are possible: DIN, ASME or SAE. The easy-to-change cartridge technology allows the pump core to be replaced in just a few minutes, which simplifies maintenance and reduces downtime.

The pump features a fully hardened spindle package and a patented thrust-balancing system. The thrust-compensation system ensures the delivery of low viscosities, even at high pressures. For example, pressure differences of up to 10 bars can be achieved for viscosities of 1.1 centiStoke (cSt).

Initially, Leistritz is launching pump sizes for flowrates of 7–564 L/min. The series will successively be expanded by eight additional sizes with flowrates up to 1,600 L/min.

A steam-stable MOF for high-capacity carbon capture

A recently discovered family of highly porous metal-organic framework (MOF) materials is showing promise in carbon-capture applications. Researchers from University of California, Berkeley (www.berkeley.edu), Lawrence Berkeley National Laboratory (LBL; www.lbl.gov) and ExxonMobil Corp. (Irving, Tex.; www.exxonmobil.com) demonstrated the efficacy of the new tetra-amine-functionalized magnesium-based MOFs in removing CO_2 emissions — reporting a six-fold increase in effectiveness over conventional amine-based carbon-capture methods.

"This family of MOF materials has a very high density of metals in the three-dimensional porous framework, and these metals have open coordination sites. This high density means we can incorporate a large number of amine groups bound to these open metal sites in an ordered fashion, which in turn leads to the potential for a high capture capacity for CO_2," explains Simon Weston, senior research associate and the project lead at ExxonMobil Research and Engineering Co. He adds that while earlier research looked at incorporating diamine groups into the MOF, which only provided one attachment point for CO_2, switching to tetra-amines provided additional attachment points and also served to improve the material's thermal stability during steam cycling. This stability enables regeneration (and therefore, repeated re-use) of the material using steam at relatively low temperatures (110–120°C), which decreases overall energy consumption when compared to other carbon-capture methods.

The team's work has demonstrated that the MOFs are highly selective for CO_2 and could capture over 90% of the CO_2 emitted from industrial sources. The combination of this high CO_2-capture capacity alongside thermal stability and ease of regeneration using low-temperature steam make this material an attractive prospect for industrial carbon capture. However, notes Weston, the technology has thus far only been demonstrated at laboratory scale, and additional work will be required to progress the technology to a larger-scale pilot.

Edited by:
Gerald Ondrey

SMART STIR BAR

Scientists at the University of Warwick (Coventry, U.K.; www.warwick.ac.uk) have developed a magnetic stir bar with an integrated process monitoring system. Described in a recent issue of *ACS Sensors*, the Smart Stirrer has an integrated microprocessor and a number of sensors encapsulated with a magnet in the shape of a conventional laboratory stir bar. In addition to mixing the solution, the Smart Stirrer wirelessly transmits, via Bluetooth, a number of properties to a computer. The concept is said to be valuable to R&D laboratories in the chemical process industries (CPI) because it allows wireless monitoring of several parameters of a chemical reaction simultaneously. Properties that can be monitored are color, transparency, conductivity, viscosity and temperature. The next version of the device will be smaller and incorporate more sophisticated sensors, says Dmitry Isakov, assistant professor at the Warwick Manufacturing Group, and leader of the study.

NEW FCC CATALYST

BASF SE (Ludwigshafen, Germany; www.basf.com) introduced Altrium, a new fluid-catalytic cracking (FCC) catalyst for mild to heavy residual (resid) feedstock. Altrium incorporates BASF's newest Advanced Innovative Matrix (AIM) and the proven technology IZY (Improved Zeolite-Y). It has been optimized to increase the yield of transportation fuels (gasoline and distillate), while having a deeper coke-selective bottoms conversion of resid feeds. Commercial trials have confirmed Altrium's benefits.

BASF's AIM technology consolidates several novel matrix technologies that are selectively incorporated into the catalyst design for a broad selection of performance targets and applications. AIM technology enhances the performance of the FCC catalysts through the creation of a unique meso-pore

(Continues on p. 8)

architecture to improve access for heavy resid molecules and improves the metals tolerance of the catalyst. Linking the AIM technology together with IZY technology creates this unique catalyst, says the company.

METHANOL SYNTHESIS

Although the copper/zinc-oxide/aluminum oxide catalyst used for methanol synthesis has been deployed for decades, it has not been possible to analyze the structure of the surface of these catalysts under reaction conditions. Now, researchers from Ruhr-Universität Bochum (RUB; www.techem.rub.de) and the Max Planck Institute for Chemical Energy Conversion (MPI CEC; Mülheim, both Germany; www.cec.mpg.de) have learned about the structure of the catalyst's active sites, which they reported last month in *Nature Communications.*

The team showed that the zinc component of the active site is positively charged and that the catalyst has as many as two copper-based active sites. "The state of the zinc component at the active site has been the subject of controversial discussion since the catalyst was introduced in the 1960s," says professor Martin Muhler, head of the Dept. of Industrial Chemistry at RUB and Max Planck Fellow at MPI CEC. "Based on our findings, we can now derive numerous ideas on how to optimize the catalyst in the future," he says.

The study was performed as part of the Carbon-2-Chem project, which aims to reduce CO_2 emissions by utilizing metallurgical gases produced during steel production for the manufacture of chemicals. In combination with electrolytically produced H_2, metallurgical gases

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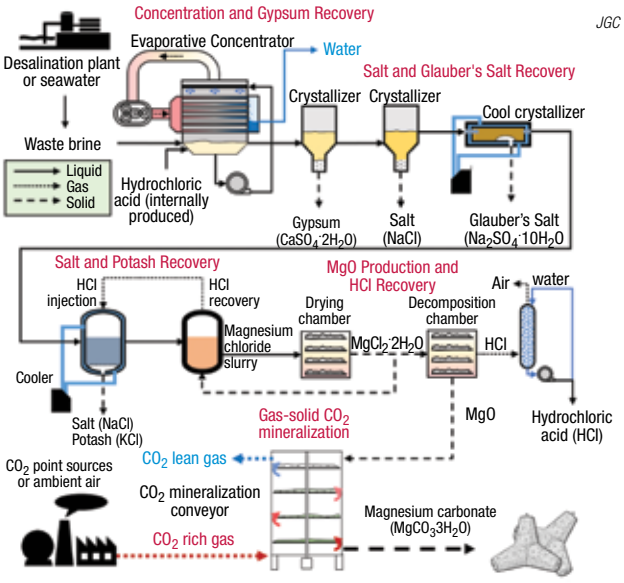
New Japanese project targets CO_2 and brine utilization



Among the goals of the project are to develop a technology to react CO_2 with the magnesium recovered from seawater to produce $MgCO_3$, a resource that can be used as a building material, such as the aggregate in concrete. If this technology is established and commercialized, it is expected to lead to a significant reduction in CO_2 emissions while effectively utilizing waste.

Because seawater and desalination brine are abundant, this technology is expected to provide a significant amount of CO_2 reductions. The other major ions in seawater and brine (calcium, sodium, potassium and sulfur) are also converted into industrial products (gypsum, salt, fertilizer, sodium sulfate and hydrochloric acid) without adding any additional chemicals. Additional fresh water is also produced. This production of multiple commodities increases profitability of the process.

Among the tasks for developing the overall process (flowsheet), Waseda University is responsible for: the development of a process to produce MgO from waste brine and MgO from $MgCl_2$; the development of a process for gas-solid mineralization of CO_2 using MgO; and the evaluation of $MgCO_3$ usage in concrete. JGC will evaluate the usefulness of $MgCO_3$, as well as study the feasibility for process scale-up and implementation. Sasakura Engineering will develop a low-energy nanofiltration (NF) method for producing $MgCl_2$. NF membranes selectively allow monovalent ions, such as Na^+ and Cl^-, to pass through while preventing the transmission of divalent ions and pigments. This makes it possible to extract magnesium efficiently.

Upcycled silicon improves LIB energy storage

Silicon is seen as a promising alternative to graphite in lithium-ion battery (LIB) anodes, due to its abundance and higher energy-storage capability — silicon is said to store ten times more energy than graphite in LIB applications. However, manufacturing processes for silicon-based battery materials have been hampered by complexity, toxicity and high costs, making them infeasible for large-scale production. Advano (New Orleans, La.; www.advano.io) is addressing these scale issues with their new processing technology. "Advano eliminates the toxic process of producing silicon, as well as harmful mining or quarrying of silica sand, by upcycling scrap silicon waste from semiconductor and solar-panel manufacturing," explains Alexander Girau, Advano founder and CEO. "By leveraging manufacturing technologies and infrastructure that already exist, Advano can provide batteries that output more power and are cost-efficient," adds Girau.

Advano has applied a proprietary surface-functionalization platform to its silicon material, A-SiFx, which enables precise manipulation of material surface and supports compatibility with polymer and solid-electrolyte components, making it easier to incorporate into an anode. "Advano has engineered a silicon solution to prevent swelling and create a permeable solid-electrolyte interphase layer, overall enhancing the battery charging cycle," says Girau. Advano's A-SiFx is currently used as an additive to improve the energy storage of LIBs, and eventually will be used to fully replace graphite, resulting in optimized anode energy density. Earlier this year, Advano opened its first manufacturing facility, located in New Orleans. The new facility is slated to produce 10 ton/yr of A-SiFx by the first quarter of 2021. The company also recently announced its first commercial partnership, with Mitsui Kinzoku SBI Material Innovation Fund, a joint venture between Mitsui Kinzoku and financial services firm SBI.

Coretec partners with Evonik to produce cyclohexasilane

The Coretec Group Inc. (Ann Arbor, Mich.; www.thecoretecgroup.com) recently entered a supply partnership with specialty chemical company Evonik Industries AG (Essen, Germany; www.evonik.com) in which Evonik will produce cyclohexasilane (CHS; Si_6H_{12}) for application development using intellectual property developed by Coretec. Coretec has developed a proprietary process for synthesizing CHS, a precursor of pure silicon.

Under the agreement, Evonik will produce 50-g samples of CHS by the end of 2020 for use by industrial customers in the development of silicon applications, such as Si quantum dots for next-generation (specific-frequency) LED lights, Si anodes for Li-ion batteries and low-power semiconductor computer chips.

Coretec CEO Michael Kraft notes that the company's new process for CHS synthesis enables safe and low-cost production of CHS. Users can now take advantage of CHS's unique properties, such as making high-purity amorphous Si at low temperatures. The physical properties of amorphous Si differ from crystalline Si, and are critical to the use of Si in quantum dots and other applications, he says.

Further, CHS is a liquid at ambient temperature and pressure, and allows the delivery of high-purity silicon to various manufactured products in a liquid form, and at much lower temperatures than would be required for gas-based plasma-deposition of Si. This reduces manufacturing costs and may eliminate certain manufacturing steps in making Si-containing technology products, Kraft says.

Coretec has filed for patents on the intellectual property associated with the new CHS synthesis process, which differs from a previous process under development by Coretec, which could not be scaled effectively (*Chem. Eng.*, September 2016, p. 10).

could also serve as a starting material for sustainable methanol synthesis.

For the project, Muhler collaborated with Bochum-based researcher Daniel Laudenschleger and Mülheim-based researcher Holger Ruland.

OIL-ADSORBING MATS

Researchers from King Abdullah University of Science and Technology (KAUST; Thuwal, Saudi Arabia; www.kaust.edu.sa) have developed an intrinsically porous polymer with a very high internal surface area that could be an ideal material for soaking up oil spills. The polymer's structure also incorporates hydrophobic trifluoromethyl groups, which enables the material to reject water while adsorbing non-polar liquids, such as oil.

The polymer is composed of a fluorinated polyimide (PIM-PI) with a high Brunauer–Emmett–Teller (BET) surface area of 565 m^2g^{-1}. The nanofibrous sorbent is produced by electrospinning of PIM-PI (6FDA–TrMPD), which was synthesized by a one-pot, high-temperature polycondensation reaction between 4,4'-(hexafluoroisopropylidene)diphthalic anhydride (6FDA) and 2,4,6-trimethyl-*m*-phenylenediamine (TrMPD). Electrospinning of 6FDA–TrMPD from a solution of dimethylformamide (DMF) produced ultrafine nanofibers. The developed sorbent showed high sorption capacities of 25–56 g per gram of sorbent for a variety of oils and non-polar solvents,

(Continues on p. 10)

according to the researchers, which reported the study in *Environmental Science Nano*.

The researchers are now working to create membranes and fibrous sponges of the material.

'POROUS LIQUIDS'

A new material that promises to save up to 80% of the energy used to separate propylene from propane (by distillation) has been developed by a team of researchers from the Karlsruhe Institute of Technology (KIT; Germany; www.kit.edu), Leibniz Universität Hannover, KAUST and the German Institute of Rubber Technology e.V. (Hannover).

As described in a recent issue of *Nature Materials*, the researchers have been able to distribute a metal-organic framework (MOF) in a liquid for the first time. To do this, they started with the solid material ZIF-67 (zeolitic imidazole framework), whose atoms form a MOF with 0.34-nm wide pore openings. By systematically modifying the surface of ZIF-67 nanoparticles, it becomes possible to form a dispersion of the MOF in liquids, such as cyclohexane, cyclooctane or mesitylene. Because propylene is retained in the pores of this so-called porous liquid, it can effectively be separated from smaller molecules that pass through more quickly.

The researchers also produced mixed-matrix membranes from a plastic material containing up to 47.5% of the chemically modified ZIF-67. Two such membranes arranged in series were able to produce propylene with 99.9% purity from a gas mixture containing equal parts of propylene and propane — even though the molecules differ in size by just 0.2 nm.

The flowrate was at least three times higher than alternative membranes, which makes the new membranes even more promising as an alternative to conventional distillation separation.

WATER SPLITTING

A team of scientists led by Nanyang Technological University, Singapore (NTU Singapore; www.ntu.edu.sg) have discovered the parameters that deter-

(Continues on p. 11)

A zinc-based catalyst makes syngas by co-electrolysis

Researchers from the University of New South Wales (Sydney, Australia; www.unsw.edu.au), led by professor Rose Amal, have shown that by making zinc oxide at very high temperatures using a technique called flame spray pyrolysis (FSP), they can create nanoparticles that catalyze the co-electrolysis of CO_2 and water into synthesis gas (syngas; H_2 + CO). The researchers believe the method is less expensive and more scalable to the requirements of heavy industry than the methods available today.

In the process, humidified CO_2 is fed to the electrolyzer. The ZnO catalyst is designed with two active sites, thereby simultaneously converting CO_2 into CO, and H_2O into H_2. The H_2-to-CO ratio (H/C ratio) can be varied by making small adjustments to the way the nanoparticles are burned by the FSP technique. This feature makes it possible to tailor the catalyst to meet the requirements for end-use applications.

The researchers say past attempts have used expensive catalyst materials, such as palladium, but their method is the first instance where an inexpensive and abundant material has been successfully applied to waste CO_2 conversion.

The next phase of the research is to test the nanomaterials in a fluegas setting to ensure that the new catalyst can withstand the harsh conditions and other chemicals found in industrial waste gas.

Improved process for treating AMD waste recovers more rare earth elements

By modifying a traditional treatment method for acid mine drainage (AMD), researchers at Penn State University (PSU; State College, Pa.; www.psu.edu) were able to both reduce the amount of chemicals required for treatment and increase the amount of rare earth elements (REEs) recovered from the waste.

AMD is an acidic aqueous runoff that occurs when iron sulfide exposed to air and water by coal mining activity oxidizes and generates sulfuric acid. The sulfuric acid solution dissolves surrounding rocks, drawing a variety of toxic metals into the water. AMD is a major environmental hazard for plants, animals and humans, and is treated traditionally by collecting the AMD in retention ponds and neutralizing the acid with hydroxides. This causes toxic metals to precipitate as a sludge.

The PSU team developed a novel, staged-precipitation processes for AMD that incorporates CO_2 mineralization. Adding gaseous CO_2 to the AMD produces chemical reactions that result in the formation of insoluble metal carbonates, the scientists say. The rare earth elements bond with the extra carbonate anions and precipitate out of the water at lower pH values. The PSU study, published in *Chem. Eng. J.*, represents the first time CO_2 mineralization has been used to recover REEs from AMD.

The staged precipitation process with CO_2 mineralization raised the level of REEs recovered by 15 percentage points compared to traditional methods, while also suppressing the formation of iron precipitates, which can complicate downstream REE purification.

The PSU researchers say the process can also be applied for the recovery of critical elements from other low-concentration pregnant leach solutions.

Waste-based rubber can be joined or repaired catalytically

A new sustainable rubber that can, with an amine catalyst, be repaired and returned to its original strength in minutes, has been discovered by researchers from Flinders University (Adelaide, Australia; www.flinders.edu.au), the University of Western Australia (Perth), and the University of Liverpool (U.K.). "This study reveals a new concept in the repair, adhesion and recycling of sustainable rubber," says Justin Chalker, research leader and professor at Flinders University. "Too many rubbers, plastics and ceramics are not recyclable," says Chalker.

The new rubber can be made from industrial waste products, such as sulfur and canola cooking oil, and dicyclopentadiene (DCPD). It is produced by means of inverse vulcanization, which is a copolymerization of elemental sulfur and alkenes. These polymers contain a polysulfide network that creates many opportunities for processing, assembly and repair that are not possible with traditional rubbers, plastics and thermosets. The researchers have shown that two surfaces of these sulfur-containing polymers can be chemically joined at room temperature through a phosphine- or amine-catalyzed exchange of the S–S bonds in the polymer. Rubber bricks made out of these polymers can be chemically joined by applying the catalyst.

These new polymers have potential applications in energy storage, adhesives, infrared optics and environmental remediation.

New fabrication method for fluorine-containing carbon-capture membranes

Recent work by a team of researchers from Oak Ridge National Laboratory (ORNL; Oak Ridge, Tenn.; www.ornl.gov) and the University of Tennessee (Knoxville; www.utk.edu) has brought cost-effective, fluorinated carbon molecular-sieve membranes within closer reach. To make the membrane, the researchers used a sol-gel polymerization process in which a fluorine-containing substrate that also contains nitrile and ether groups is polymerized using strong Brønsted acid (CF_3SO_3H) as a promoter/catalyst. The reaction is performed in a way that allows the scientists to regulate the size and thickness of the obtained polymer membrane. Subsequently, the polymer film is carbonized in a tubular oven at 500°C under a slow stream of nitrogen gas to generate the carbon molecular-sieve-based membrane, explains Ilja Popovs, ORNL Nanomaterials Chemistry Group scientist. The high fluorine content in the polymer improves its ability to adsorb and separate CO_2 from nitrogen and water vapor, which are prominent components of exhaust gas, Popovs adds.

By carefully controlling the carbonation temperature in the oven, the researchers were able to control the porosity of the membrane, which leads to greater permeability, but at the expense of selectivity. "We were able to identify a 'sweet spot' in the temperature and the thickness of membrane that provides the best combination of transport properties (permeability) and separation (selectivity)," Popovs reports.

The ORNL-led group demonstrated the effectiveness of their membrane on a gas stream of nitrogen, carbon dioxide and water, simulating industrial fluegas. The experimental results suggest the materials are "promising candidates for CO_2 separation." ■

mine the efficiency of a class of low-cost catalysts, called spinel oxides. The discovery is said to break a bottleneck in the production of H_2 from water electrolysis.

Spinel oxides, which are typically made from inexpensive transition metals, are interesting as a stable, low-cost catalyst for water splitting, but the design of high-performing spinel oxides has been hampered by the lack of understanding of how they work. Now, NTU Singapore's associate professor Jason Xu Zhichuan and his team have made two important advances. They have unravelled, at the atomic scale, how spinel oxides work to speed up water electrolysis, and then used machine learning to select new spinel oxides with increased catalytic activity.

Based on key parameters that the team had identified, the team trained a machine-learning model with a dataset of over 300 spinel oxides in order to screen and predict the efficiency of any spinel oxide catalyst in a matter of seconds. Using this method, the team found that a new oxide comprising manganese and aluminum was predicted to show superior catalytic activity. This was validated experimentally.

These findings, as described in *Nature Catalysis*, have the potential to improve industrial-scale production of H_2 by electrolysis. (For more on water electrolysis, see the Cover Story on pp. 26–30.) ❐

LINEUP

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Plant Watch

Phillips 66 to transform refinery into world's largest renewable-fuels plant

August 13, 2020 — Phillips 66 (Houston; www.phillips66.com) plans to reconfigure its petroleum refinery in Rodeo, Calif. to produce renewable fuels from used cooking oil, fats, greases and soybean oils, resulting in the production of 680 million gal/yr of renewable diesel, renewable gasoline and sustainable jet fuel. Combined with the production of renewable fuels from an existing project in development, the plant would produce more than 800 million gal/yr of renewable fuels, making it the world's largest facility of its kind.

OCP to double phosphoric acid production with construction of new plant

August 12, 2020 — OCP Group (Casablanca, Morocco; www.ocpgroup.ma), through subsidiary Euro Maroc Phosphore (EmaPhos), is building a new plant for the production of purified phosphoric acid. This new plant will double EmaPhos' phosphoric-acid production capacity from 140,000 metric tons per year (m.t./yr) to 280,000 m.t./yr, beginning in the 4th quarter of 2022.

Nouryon to expand MCA production capacity in the Netherlands

August 7, 2020 — Nouryon (Amsterdam, the Netherlands; www.nouryon.com) plans to expand its production capacity for monochloroacetic acid (MCA) in Delfzijl, the Netherlands by the end of 2020. Nouryon has also initiated a study to free up more capacity for chlorine, a key raw material for MCA.

Repsol begins production of aviation biofuels in Spain

August 5, 2020 — Repsol S.A. (Madrid, Spain; www.repsol.com) has produced the Spanish market's first batch of bio-based aviation fuels. The biofuels were produced at Repsol's Puertollano Industrial Complex in Ciudad Real, and more batches of aviation biofuel will continue to be manufactured at other Repsol facilities across Spain. The first batch consists of 7,000 m.t. of aviation fuel made from biomass.

Johnson Matthey technology chosen for world's largest single-train methanol plant

August 5, 2020 — Johnson Matthey (London, U.K.; www.matthey.com) has been selected by Ningxia Baofeng Energy Group as licensor for the third methanol-synthesis plant at its coal-to-olefins complex near Yinchuan in Ningxia Province, China. With a planned capacity of 7,200 m.t./d, the methanol plant will be the largest single-train methanol plant in the world once completed.

Sabic to operate chemical plant on 100% renewable power

July 29, 2020 — In Cartagena, Spain, the polycarbonate facility operated by Sabic (Riyadh, Saudi Arabia; www.sabic.com) is set to become the first large-scale chemical-production site to be run entirely on renewable power, following the signing of a major agreement with Iberdrola, a world-scale electric utility company. Iberdrola will invest almost €70 million to construct a 100-MW solar photovoltaic facility with 263,000 panels on land owned by Sabic, making it the largest industrial renewable-power plant in Europe. The plant is expected to be fully operational in 2024.

Air Liquide to invest €125 million in advanced oxygen-production plant

July 23, 2020 — Air Liquide S.A. (Paris, France; www.airliquide.com) announced an investment of €125 million to build the first world-scale air separation unit (ASU) for oxygen production with an energy-storage system that facilitates more renewable energy on the electricity grid due to its grid-stabilizing capability. This plant will have an oxygen production capacity of 2,200 m.t./d, and will be built in Port of Moerdijk, the Netherlands. With operations slated to begin in 2022, the system allows for the storage of up to 40 MWh of energy.

Mergers & Acquisitions

BASF acquires glass-fiber 3D-printing business from Owens Corning

August 10, 2020 — Forward AM, the 3D-printing business of BASE SE (Ludwigshafen, Germany; www.basf.com), has acquired the Xstrand business line from Owens Corning (Toledo, Ohio; www.owenscorning.com). The acquisition of Xstrand enables Forward AM to expand its portfolio with advanced glass-fiber-reinforced filaments for 3D printing.

BASF acquires alkoxylate production assets from Sinopec

August 7, 2020 — BASF will increase its alkoxylate capacity through the acquisition of land, buildings and production assets from Sinopec Shanghai Petrochemical Co. The acquired facilities adjoin the existing BASF Jinshan site. With the current alkoxylate line in the Jinshan plant running at full capacity, this acquisition will double the alkoxylate production capacity at Jinshan.

Momentive to sell sealants business to Henkel

August 5, 2020 — Momentive Performance Materials Inc. (Waterford, N.Y.; www.momentive.com) announced the sale of its Consumer Sealants business to Henkel AG & Co. KGaA (Düsseldorf, Germany; www.henkel.com). Momentive will

continue to manufacture consumer-line products through 2021. The move away from consumer sealants will enable greater focus on unique silicones and specialty applications.

Air Liquide to acquire 16 ASUs from Sasol

July 29, 2020 — Air Liquide will acquire the biggest oxygen-production site in the world from Sasol Ltd. (Johannesburg, South Africa). Located in Secunda, South Africa, the site comprises 16 ASUs with an installed capacity of 42,000 m.t./d. The amount of the initial investment is approximately €440 million.

Total sells Lindsey refinery to the Prax Group

July 27, 2020 — Total SE (Paris, France; www.total.com) agreed to sell its Lindsey petroleum refinery, located in Immingham, U.K., and associated logistic assets, as well as all of the related rights and obligations, to the Prax Group. The Lindsey refinery has production capacity of 5.4 million m.t./yr.

Ashland to sell its maleic anhydride business

July 27, 2020 — Ashland Global Holdings Inc. (Wilmington, Del.; www.ashland.com) announced a definitive agreement to sell the company's maleic anhydride business and manufacturing facility in Neal, W. Va. to AOC Materials LLC for $100 million. The transaction with AOC is expected to close prior to the end of 2020.

Baker Hughes sells specialty polymers business to SK Capital

July 27, 2020 — Baker Hughes (Houston; www.bakerhughes.com) agreed to sell its specialty polymers business to SK Capital Partners, LP. The specialty polymers business, with manufacturing operations in Barnsdall, Oklahoma, produces low-molecular-weight olefin polymers, including a range of differentiated functional polymers and premium, high-melting-point polyethylene waxes.

Total and IOCL form JV focused on bitumen derivatives

July 27, 2020 — Indian Oil Corp. Ltd. (IOCL; New Delhi, India) and Total announced the formation of a 50:50 joint venture (JV) that will manufacture and market bitumen derivatives and specialty products in India. The JV will set up manufacturing sites across India.

Stepan acquires Clariant's anionic surfactant assets in Mexico

July 20, 2020 — Stepan Co. (Northfield, Ill.; www.stepan.com) has entered into an agreement to acquire Clariant AG's (Muttenz, Switzerland; wwww.clariant.com) anionic surfactant business and associated sulfation equipment located in Santa Clara, Mexico. The transaction is expected to close in the third quarter of 2020.

Celanese sells $1.5-billion stake in Polyplastics JV to Daicel

July 20, 2020 — Celanese Corp. (Dallas, Tex.) reached a definitive agreement to sell its 45% equity investment in the Polyplastics joint venture (JV) to Daicel Corp. (Osaka, Japan; www.dailcel.com) for $1.575 billion. Following the completion of the transaction, Daicel will own 100% of Polyplastics. ■

Mary Page Bailey

Focus on Valves

GEMÜ

Posi-flate

Asahi/America

Cowan Dynamics

A new motorized control valve for the semiconductor industry

The 2/2-way diaphragm globe valve C53 iComLine (photo) was developed for precise and demanding control applications in semiconductor production. The sealing concept of the valve is based on the company's PD design, with actuator and medium separated by a regulating cone made of resistant polytetrafluoroethylene (PTFE). As the regulating cone contour, actuator stroke and connection size can be customized, the C53 iComLine satisfies virtually all control and flow requirements of the high-tech semiconductor industry. Thanks to the combination of the precise stepper motor with ultrapure body materials, the valve is particularly suitable for lithography, CMP and etching processes, as well as applications in the analysis field of any semiconductor production process. *— GEMÜ Valves, Inc., Atlanta, Ga.*
www.gemu-group.com

Stainless steel butterfly valve seals with inflatable seat

The Posi-flate butterfly valve with a highly polished 316 stainless-steel housing and disc (photo) is suitable for many applications, such as food, chemical and pharmaceutical manufacturing. The inflatable seat design of this butterfly valve provides a better seal by utilizing air pressure to expand the seat against the disc, providing more sealing area and an even pressure distribution against the disc every time. The seat automatically compensates for wear when it inflates against the disc, extending valve life considerably. Because the Posi-flate disc only makes casual contact with the seat during opening and closing, torque requirements are substantially lower. The Posi-flate stainless-steel butterfly valve is available in sizes ranging from 2 to 20 in. *— Posi-flate, St. Paul, Minn.*
www.posiflate.com

A new ball valve for precision flow control

The Type-21a Seat Support Technology (SST) flow-control ball valve (photo) offers all of the robust elements of the Type-21 and the ability to precisely control flow. Available in ½- to 2-in. sizes, the SST ball valve features a precision-machined polyvinylchloride (PVC) ball with center provisions to support PTFE seats from 0 to 100% of capable flow. The Type-21a SST ball valve produces equal-percentage flow characteristics for fine throttling. The valve requires directional installation and comes equipped with a flow-direction label. Manually operated SST ball valves include a 0-to-100 deg indicator plate and an indicator line on the handle, which doubles as a carrier adjustment tool. The valve body is PVC with either EPDM (ethylene propylene diene monomer) or FKM (fluoroelastomer) O-rings. *— Asahi/America, Lawrence, Mass.*
www.asahi-america.com

This new valve actuator takes up less space

Launched in March, the E2HR Series Electro-Hydraulic rotary valve actuators (photo) are said to pack high performance into the smallest possible installation envelope for ¼-turn valve-actuating applications. All hydraulic components and sensors are integrated into a single compact manifold block that also houses the actuator and integral oil reservoir. The control panel can be mounted directly to the manifold block or installed remotely to run multiple units from a single control panel. This self-contained actuator can be installed either vertically or horizontally and has no external piping. The actuator delivers a torque of up to 300,000 in-lb, has a duty cycle of 100% and can operate at temperatures from –50 to 40°C. Partial-stroke testing can be initiated from the touchscreen or remotely. *— Cowan Dynamics, Inc., Montreal, Que., Canada*
www.cowandynamics.com

Bellows seal valves for when leakage is not an option

Low-pressure ASME Class 150-900 Clampseal bellows seal valves (photo, p. 15) are suitable for demanding toxic, corrosive and caustic applications, as well as regulation of severe-service process control where

leakage to the environment is not an option. They feature low weight and seismic profile; leak-proof integrity; in-line servicing; high cycle bellows; high flow capacity; and no fugitive emissions. The valves are available in ½- through 4-in. sizes with socket weld, butt weld, flange and threaded end connections. High-pressure Clampseal single- and double-bellows seal valves for up to ASME Class 2500 are suitable for applications where packed valves may not reliably contain light gases or hazardous system fluids due to leakage in the stem/packing seal area or stuffing box wall/packing seal area. — *Conval, Inc., Enfield, Conn.*
www.conval.com

Ball valve brings added safety to high-flow applications

The full-bore, bidirectional flow-capable GB Series ball valve (photo) is engineered to provide high flowrates at a working pressure of 6,000 psig (413 bars) while simplifying installation, minimizing rework requirements, and delivering the reliable shutoff performance needed to keep workers safe and systems operating efficiently in a variety of demanding applications. Integral end connections range in size from 3/8 to 1 in. To reduce corrosion in harsh environments, the GB Series ball valve is available in a variety of alloy materials, such as 6-Moly, Alloy 2507 and Alloy C-276, as well as materials selected in accordance with NACE MR0175 for sour-gas applications. The valve also complies with ASME B31.1 and B31.3 standards for power and process piping systems. — *Swagelok Co., Solon, Ohio*
www.swagelok.com

Smart actuator optimizes control-valve performance

The new Smart Electric Valve Actuator (SEVA; photo, p. 16) withstands extreme conditions while providing exceptional position accuracy. The SEVA now offers Modbus RTU, Modbus TCP/IP and SoloCUE connectivity. SoloCUE is a software solution that provides easy access to the setup of both the feature-rich SEVA and its protocols. This cus-

Conval

Swaglok

Badger Meter

tom-built, bulletproof platform allows end-users to visualize SEVA's performance and setup characteristics. SEVA is designed for extreme conditions, and the actuator has military-grade components. SEVA has 100- and 200-lb thrust models. There are several options available for communication protocols, including Modbus RTU, Modbus TCP/IP and the Industrial Ethernet Protocol (EtherNet/IP). It is certified by FM, EX, CSA and CE. The actuator allows for both linear and Device Level Ring (DLR) ring network topologies. — *Badger Meter, Milwaukee, Wis*.
www.badgermeter.com

All-in-one pump protection automatic recirculation valves

The new, self-modulating TDL Automatic Recirculation Valves (photo) in 10 and 12 NPS are now available with high bypass flow, offering maximum flexibility in bypass trim sizes for pumping systems. These reliable all-in-one pump-protection valves are designed to keep pumping systems modulating and running smoothly, without cavitation, vibration or overheating. Without minimum flow, a pump can quickly suffer grave damage, causing downtime and costly repairs — but control valves for recirculation require continuous control of complex equipment, a flow measurement device, control unit and energy supply. Unlike control valve packages, these self-operated flow-sensitive valves operate without a separate power supply or any control system, and begin protection immediately once installed. — *Schroedahl GmbH, a subsidiary of Circor International, Reichshof-Mittelagger, Germany*
www.schroedahl.de

Schroedahl

Emerson

New virtual valve-repair service offers immediate support

The new Remote Assistance service capability (photo) was launched in April to help plant operators immediately respond to industrial valve issues by using augmented reality (AR) technology. The AR technology uses a robust, secure channel certified as ISO 27001-compliant. Valve repairs are advised and guided by this company's experts as part of its expanding Connected Services portfolio in its Plantweb digital ecosystem. Using a mobile device, plant personnel can securely share their field of view through the AR software as valve experts help troubleshoot and solve valve problems. Step-by-step instructions are overlaid in the field-user's application to support installation, calibration or repair actions. The Remote Assistance service is available for this company's valve, actuator and regulator product portfolios, and in some instances, can cover other companies' products. — *Emerson, Marshalltown, Iowa*
www.emerson.com

Rotork

A host of check valves for trouble-free performance

This company's Surgebuster, Dual Disc, Silent Check and Sure Seal Foot Valve check valves are highly engineered to provide long life and trouble-free performance. Engineers weigh the importance of slamming characteristics as one of the factors when selecting a check valve. All check valves are designed with non-slam characteristics, such as the seat angle of the Surgebuster. The Surgebuster also uses the addition of the Disc Accelerator to prevent slamming in the most severe applications. The compact wafer design has made the Dual Disc a popular choice when space is a concern. The short linear stroke and spring-return action of the Silent Check Valve combine to effectively eliminate surges and water hammer that can be associated with the sudden stoppage of a reverse flow. The versatile Foot Valve can provide positive seating action at both low and high pressure without slamming. — *Val-Matic Valve & Manufacturing Corp., Elmhurst, Ill.*
www.valmatic.com

A new, enhanced digital smart positioner

The new enhanced YT-3700 and YT-3750 digital smart positioners (photo) can be used for both control and on/off valve applications where diagnostics are required. The YT-3700 and YT-3750 pneumatic smart positioners employ continuous monitoring and graphic display of valve position, setpoint target over time and internal circuit board temperature over time. Valve diagnostic information to NE107 standard is provided, with HART 7 communication protocol included as standard and a display for all settings and local device interaction. Commissioning can

be handled locally without the need for an additional device. — *Rotork plc, Bath, U.K.*
www.rotork.com

Compact ball valve handles heavy-duty applications

As first shut-off valve or for connecting pressure measuring instruments, the new model BV ball valve (photo) is suitable for a variety of applications. It is available in process and instrument versions. The instrumentation valve is compact and can therefore also be integrated in space-restricted environments, such as a control panel. Thanks to its robustness, the model BV is suitable for heavy-duty applications and processes with critical media. Its pressurized parts correspond to the safety factor 4:1, its leak tightness has been tested in accordance with BS 6755 / ISO 5208, leakage rate A. An antistatic design, a blow-out-proof valve spindle and self-relieving valve seats ensure the safe operation of the ball valve. — *WIKA Alexander Wiegand SE & Co. KG, Klingenberg, Germany*
www.wika.com

New members added to this line of valves

This company's line of air-piloted valves now includes the APVS Media Separated Valve Series (photo). This new series is comprised of four different styles of APVS valves and provides many versatile options for handling caustic media, all while allowing safe operation in volatile areas. The series includes inert gas/spring-operated valves to control high-purity, aggressive and corrosive liquid chemicals while allowing a flowrate superior to other similar valves on the market. Each APVS Valve can be configured to meet critical user requirements with ordering options that include various port sizes, diaphragm seal materials, pilot options and valve function. In addition, an optional magnetic piston is available for end-of-stroke position sensing and can be combined with a magnetic position sensor to maintain positive feedback. — *Spartan Scientific, Youngstown, Ohio*
www.spartanscientific.com

Gerald Ondrey

Wika

Spartan

Level Measurement and Control

Yokogawa

Levelese

Emerson

Outotec

Ambient temperature swings handled by this DP transmitter

For tanks located outdoors, ambient temperature conditions can interfere with level measurement due to the expansion and contraction of oil inside capillary tubes that are connected to diaphragm seals. The EJXC80A Diaphragm Seal System (photo) was designed with a unique compensating capillary specifically to address this issue. The compensating capillary is an additional capillary tube on the high-pressure side of the transmitter that balances the volume of fill fluid with the capillary on the low-pressure side. This allows both the high- and low-side fill fluids to be exposed to the same conditions and effectively eliminates errors caused by changes in ambient temperature. By reducing variability in tank measurements, chemical storage capacity can be increased and operators can better manage production targets. In addition, there is no need to perform manual checks to confirm tank levels and periodically re-zero the transmitter. — *Yokogawa Corp. of America, Sugar Land, Tex.*
www.yokogawa.com/us

A compact level sensor for corrosive service

The LevelBest compact-mount level sensor and transmitter (photo) has been specifically designed for corrosive-service applications, such as acids or caustics in moist, salty atmospheres. The body is made of 304 stainless steel, with a polycarbonate NEMA 4X electronic and terminal block enclosure that is sealed and separate. Other features include a smart two-wire electronic transmitter with remote HART-like communications; a 2-in. NPT connection; and local or remote calibration over two-wire 4–20-mA signal leads. The device measures over the range of 3 in. to more than 166 ft. The instrument is based on the principle of buoyancy, whereby the LevelBest weighs an inert chain, and determines the inverse of liquid level and converts it to an analog or digital electronic signal for indication, alarming or continuous or on-demand transmission. — *Levelese, Inc., Denver, Colo.*
www.levelese.com

This radar gage is optimized for interface applications

The Rosemount 5300 guided-wave radar level transmitter (photo) has been enhanced to optimize separation-process performance and prevent costly product ingress by accurately measuring a thinner top liquid layer in interface applications. The Rosemount 5300 can now also perform measurements to the top of a tank, enabling increased throughput and profitability. Additional new features provide greater ease-of-use, increased safety and enhanced performance in the most challenging level and interface applications. In interface-measurement applications, such as separators, the top product layer must be of a certain minimum thickness for a guided-wave radar transmitter to distinguish between the echoes from the two liquids. Previously, this minimum detectable thickness would be 50–200 mm. The company's patented Peak in Peak interface algorithm now enables the Rosemount 5300 to detect a top liquid layer of just 25 mm. This further prevents unwanted product ingress. — *Emerson Automation Solutions, St. Louis, Mo.*
www.emerson.com

Expanded flotation offering has new cell and level-control

The TankCell s-Series flotation units are standardized units based on this company's proven TankCell e-Series solution, while the CellStation (photo) is an intelligent and easy-to-operate solution for controlling the air feed and pulp level in flotation cells — a task that becomes more challenging as the number and complexity of cells in a configuration increases. The solution incorporates the company's ExactLevel controller, which enables more ac-

curate level control and significantly reduces process disturbance, resulting in more stable froth conditions and therefore improvements in the flotation cell's metallurgical performance. CellStation has plug-and-play connectivity with the FrothSense sensor system, which measures the essential properties of froth, including speed, direction, bubble size, stability and color, and provides statistical data related to these variables. — *Outotec Oyj, Espoo, Finland*
www.outotec.com

A level transmitter for powders and dusty atmospheres

The Optiwave 6500C (photo) is a radar level transmitter that delivers continuous measurement in silos, hoppers and containers. The Optiwave 6500C is an optimal product for bulk storage in the mining, minerals, chemicals, power, paper, food and beverage industries. The radar offers several advanced technological features, including an 80-GHz (FMCW) bandwidth radar and a 70-mm lens antenna, making it suitable for environments with low-reflective media. With a measuring range extending over 100 m, the Optiwave 6500C handles uneven surfaces or tanks with obstacles. Other advanced features include a large backlit LCD screen with a four-button keypad, ensuring flexibility for different radar usage. — *Krohne, Inc., Beverly, Mass.*
www.us.krohne.com

Accurate level detection — regardless of media

The CleverLevel PL20 level switches (photo) utilize frequency sweep technology, which ensures accuracy and consistency regardless of the type of process medium being measured. The switches provide reliable limit detection without the need for parameterization to a specific medium, so regardless of whether the process medium is liquid, paste-like, sticky or granular, the CleverLevel PL20 recognizes them. As a consequence, they are ideal for industrial and hygienic applications, because the switches also distinguish foam and liquid as well as detecting separating layers. The device is approved to both 3A and EHEDG standards. — *Baumer Ltd., Watchfield Swindon, U.K.*
www.baumer.com

GWR transmitter operates in harsh processing conditions

The new Eclipse Model 700 guided wave radar (GWR) transmitter is designed to be virtually unaffected by changing media conditions, including turbulence, foaming, boiling and flashing. Proactive diagnostics, like the Model 700's build-up detection feature, minimize maintenance costs by allowing engineers to proactively schedule shutdowns and maximize uptime. Eclipse GWR solutions, including the new Model 700, are designed to handle any level of complexity and are equipped for overfill protection through the probe design, which allows for level measurement across the entire probe length with a smaller dead zone than alternatives. The instrument has a reference accuracy of ±0.1 in. or 0.1% of the probe length, whichever is larger. — *Magnetrol, Aurora, Ill.*
www.magnetrol.com

Level switches for packed powder applications

The GJ level switch (photo) can operate as high or low point level indicators for bulk solids that tend to pack or bridge easily. The GJ Detector operates successfully with consistent results on chemical powders, minerals and many other granulated materials. These level switches measure dry bulk solids ranging from less than 15.0 to greater than 60 lb/ft^3. The level detectors are factory calibrated and do not require any field calibration before installation. There are no moving parts and no gaskets or seals to deteriorate, providing superior performance in dusty environments. The GJ level detector relies on mechanical oscillations to determine if the probe is covered or uncovered. When combined with the EC-501A Control Unit, signals from the detector operates a single-pole double-throw relay within the control unit and users can actuate process control equipment, level alarms or indicator lights. — *Automation Products, Inc. — Dynatrol Div., Houston*
www.dynatrolusa.com ■

Gerald Ondrey

Krohne

Baumer

Magnetrol

Dynatrol

New Products

Ekato Systems

Sundyne

Ross & Son

Blue-White Industries

Liquid-solids blending with high-solids-content media

The VPT vertical process blender (photo) is said to provide 25% less torque demand and a discharge of up to 98% when compared with horizontal drum blenders, making it suitable for mixing pasty products with high solids content. The VPT features a heavy-duty, top-entry agitator, combined with a baffle system designed for liquid and solids blending to reduce both operation costs and batch times. The high impeller efficiency reduces energy input into the blend and avoids an excessive temperature rise during the batch cycle. Furthermore, the blender includes no wetted seals, which means an overall longer equipment lifecycle. — *Ekato Systems GmbH, Schopfheim, Germany*
www.ekato.com

Use this pump in applications requiring low NPSHr

The recently enhanced LMV 803Lr (photo) is a direct-drive, vertical inline centrifugal pump designed to handle high flowrates. Featuring a novel inducer technology and backswept impeller, the pump can achieve ultra-low NPSHr (net positive suction head required) without the risk of cavitation. Recent enhancements to the pump include: new throat bushing to improve seal performance for light-hydrocarbon applications; a new oil-mist bearing box, which reduces the need for periodic greasing; and an updated cryogenic design option. — *Sundyne, Arvada, Colo.*
www.sundyne.com

A high-performance mixing and pumping skid system

This company recently designed a new skid system (photo) capable of mixing and pumping low to moderately viscous products. The Model VSL-400 system features a conical vessel on a movable skid with a progressive-cavity pump rated for flowrates ranging from 10 to 30 gal/min. A 5-hp inverter-duty motor drives a flange-mounted turbine mixer equipped with two axial flow impellers. The 34-in. dia. upper blade and 18-in. dia. lower blade maintain batch uniformity from start to finish of the pumping sequence. Both mixer and pump are controlled from a weather-proof control panel, which includes a thermal-protection system that disengages the pump motor if a set temperature is exceeded. — *Charles Ross & Son Co., Hauppauge, N.Y.*
www.mixers.com

This metering pump precisely doses harsh chemicals

The Chem-Pro CD1 multi-diaphragm metering pump (photo) offers continuous pumping for gas-forming chemicals, such as peracetic acid or sodium hypochlorite. The CD1's drive technology is self-priming and will not vapor lock. The CD1 features a patented ultra-durable diaphragm, called DiaFlex, which has been designed to last the life of the pump. A brushless variable-speed motor helps achieve a large turndown ratio, promoting high accuracy. The CD1 has a feedrate of up to 7.20 gal/h (27.26 L/h), and features built-in leak detection and fittings for multiple configuration types. — *Blue-White Industries, Huntington Beach, Calif.*
www.blue-white.com

New software release for P&ID design

Last month, this company released Visio P&ID Process Designer 2020 (VPID 2020), a software platform envisioned to create smart piping and instrumentation diagrams (P&IDs) and process-flow diagrams (PFDs). VPID 2020 is equipped with enhanced functionalities on a Visio-based platform and object-oriented technology fused with intelligent and automatic features for improving the productivity of process designers. VPID 2020 is an upgraded version of Visio P&ID Process Designer and is compatible with all Microsoft Visio platforms. — *ITandFactory GmbH, Bad Soden, Germany*
www.itandfactory.com

Analog and digital interface in a single sensor

Due to Dual Channel functionality — which enables sensor operation to be analog, digital or both simultaneously — this company's process sensors, including the CombiLyz AFI conductivity

sensor and the PP20H pressure sensor (photo), work both in conventional control topologies and digital IO-Link control environments. In process automation, an analog interface is helpful for sensor integration into existing control concepts. For sensor commissioning, IO-Link provides advantages, such as easy and fast parameterization or access to secondary data. For process control, a parallel readout of conductivity or pressure is enabled via 4–20-mA analog output. IO-Link provides access to valuable secondary data, such as process and sensor temperature. Such information can detect, for instance, unusual temperature rise in containers or pipes for predictive maintenance purposes. — *Baumer MDS GmbH, Bodman-Ludwigshafen, Germany*
www.baumer.com

A new check valve with redundant sealing

The new Model CV check valve (photo) features a sealing system with a self-centering piston, which reliably prevents backflow of liquid and gaseous media. The reliability of the new instrumentation valve is mainly due to its redundant sealing, consisting of an O-ring and a metal cone. Its leak-tightness has been tested in accordance with BS6755/ISO 5208 leakage rate A. The solid-machined, robust design of the Model CV ensures high repeatability and a long service life, even in heavy-duty applications. An application-specific assembly with a measuring instrument is offered. Such an instrument hook-up is delivered ready-to-install and leak tested. — *WIKA Alexander Wiegand SE & Co. KG, Klingenberg, Germany*
www.wika.com

Transform buildings into high-performing assets

The new generation of building automation controllers, Desigo PXC4 and PXC5 (photo), offers a wide range of benefits for automating small- and medium-sized buildings. Thanks to the new, license-free Desigo Engineering Framework, devices can now be seamlessly integrated in the same framework. Both controllers were designed to expand and strengthen the Desigo portfolio and focus on one specific automation element — the Desigo PXC4 for heating, ventilation, air-conditioning (HVAC) plants; and the Desigo PXC5 for system functions and integration. The new controllers were simultaneously released with the Desigo Engineering Framework, which consists of the HIT Portal, a web-based planning and selection tool; the engineering and commissioning tool ABT Site for PC users; and the commissioning tool ABT Go application (app) for mobile use. — *Siemens Smart Infrastructure, Zug, Switzerland*
www.siemens.com

New hollow-socket shaft design for coupling-free installations

Couplings are a common failure point within drive systems. Keeping shafts aligned not only eliminates vibrations, but also prevents additional load and wear-and-tear on drive units. Unfortunately, this presents several challenges, and even the most seasoned technicians are required to adjust and shim, sometimes for hours, to get as close to perfect alignment as possible, knowing that even the slightest misalignment will ultimately shorten the lifecycle of the gear unit. The new hollow-socket shaft design for Nordbloc.1 single-reduction gear units (photo) features a shaft design that mounts directly to a pump without the need for couplings. This significantly reduces installation time and maintenance, greatly extends the operating life of the unit, and drastically reduces revenue loss as a result of unexpected downtime, says the manufacturer. — *NORD Gear Corp., Waunakee, Wis*.
www.nord.com

PLC with direct cloud connection and multiprotocol ethernet

The TBEN-L programmable logic controller (PLC; photo, p. 22) is said to be the world's first IP67 controller for industrial applications. The TBEN-L PLC not only offers an onboard Codesys PLC, but also enables a cloud connection and communication with different Ethernet protocols at the same time, thanks to its multiprotocol technology. The new Dual MAC mode enables the module to establish a connection to the automation network via


Baumer


WIKA Alexander Wiegand SE & Co.


Siemens Smart Infrastructure


NORD Gear

Turck


Gericke


Pepperl+Fuchs North America

Thermal Care


Eaton

one port and a securely separated internet connection to the cloud via the second port. Alternatively, if an internet connection to the cloud is not required, communication in two Ethernet networks is possible, for example as a Profinet device and as Profinet, Ethernet/IP or Modbus TCP master. — *Hans Turck GmbH & Co. KG, Mülheim an der Ruhr, Germany*
www.turck.com

Explosion-proof sifters separate and condition dry materials

Centrifugal sifters from the GS product line (photo) are suitable for installation in ATEX Zone 20 internal and Zone 21 external, providing a high level of protection in areas where an explosive atmosphere with a cloud of combustible dust is likely to occur or remain present continuously or for long periods of time during normal operation. The durable powder sifters include a heavy-duty motor and safety switches, an air-set solenoid valve and air-purge lip seals as standard. GS sifters pass fine particulate matter through a mesh screen and divert oversized particles to the discharge, while securing the material within a dust-tight housing. The sifters can separate granular and powdered products into two streams by particle size, removing foreign matter and can also condition materials prior to entering production. For cleaning, the screen and basket may be safely accessed and quickly removed. The GS product line comprises four models, each available with screen mesh sizes from 100–4,000 µm, throughput rates of up to 120 ton/h and a choice of surface finishes to suit the material. — *Gericke USA, Somerset, N.J.*
www.gerickegroup.com

This smartphone now has global approvals and certification

The Ex-Handy 10 intrinsically safe 4G/LTE smartphone (photo) is now globally approved for Zone 1/21 and Div. 1. The phone has also completed testing and certification for the Sprint Open Market program. Designed for harsh environments, the Ex-Handy 10 is simple and rugged, and it promotes Industry 4.0 applications in hazardous areas. Being certified for the Sprint Open Market program means the Ex-Handy 10 can be activated on the Sprint network and ensures that Sprint-specific features, like the Sprint Direct Connect Push-To-Talk service, operate reliably. The phone features IP68 protection and permissible ambient temperatures from –20 to 60°C. — *Pepperl+Fuchs North America, Twinsburg, Ohio*
www.pepperl+fuchs.com

These packaged chillers have been upgraded

This company recently updated the Accuchiller NQ series of portable and packaged chillers (photo) to include a new control system and cabinetry design. The chillers now come standard with an advanced control system with ModBus RTU and a 7-in. color touchscreen. This robust control system provides extensive diagnostic capabilities with a wide range of communication options, including Modbus, BACnet and LonWorks. Screen layouts are improved to simplify data searching. Pressure sensors are now also included as part of the control-system package. The NQ Series control-panel cabinetry is also redesigned to include an ergonomic sloped top for easy viewing and access. NQ Series chillers are available in capacities ranging from 4 to 40 tons in air-cooled, water-cooled and remote-condenser models for indoor and outdoor applications. — *Thermal Care, Inc., Niles, Ill.*
www.thermalcare.com

New cartridges and housings for water filtration

Designed for water filtration, the Beco Protect CL coreless depth-filter cartridges enable pre-filtration with absolute retention rates of 5, 10, 20 or 40 µm. This company also offers a matching cartridge housing, the Beco Integra Cart KCL (photo). The coreless depth-filter cartridges are wrapped and graded from coarse to fine, to ensure a high particle-retention capacity. The filter cartridges are 40 in. long, without end caps and outer support cage. They come with a large diameter that allows them to achieve high flowrates at low differential pressure. — *Eaton Corp., Beachwood, Ohio*
www.eaton.com/filtration ■
Mary Page Bailey and Gerald Ondrey

Cost Estimation and Risk

Department Editor: Scott Jenkins

Understanding project risks is critical to arriving at useful cost estimates. Since each capital project in the chemical process industries (CPI) is somewhat unique, it can be difficult for engineers and project leaders to price risks in their estimates and project budgets. This one-page reference provides information on project risk, contingency and accuracy in cost estimation.

Cost estimates include two main parts: the "base," which encompasses the risk-free costs, other than specific allowances, and the "risks," which include contingency, reserves, escalation and currency exchange.

Definition of terms

The following terminology is associated with cost estimates and risk.

Risk. An uncertain event or condition that could affect a project objective or business goal.

Base estimate. Estimate including allowances, but excluding escalation, currency risk, contingency and management reserves.

Allowances. Resources included in (base) estimates to cover the cost of known, but undefined, requirements for an individual activity, work item, account or sub-account.

Contingency. An amount added to allow for items, conditions or events for which the state, occurrence or effect is uncertain, and that experience shows will likely result, in aggregate, in additional costs (this excludes major scope changes, catastrophic risk events and conditions, escalation and currency risk).

Management reserves. An amount added to an estimate to allow for discretionary management purposes outside the defined scope of the project, as otherwise estimated. May include amounts that are within the defined scope, but for which company leadership does not want to fund as contingency, or that cannot be effectively managed using contingency.

Escalation. A provision in costs or prices that accounts for uncertain changes in technical, economic and market conditions over time. Inflation (or deflation) is a component of this.

Accuracy range. An expression of an estimate's predicted closeness to final actual costs or time. Typically expressed as high or low percentages by which actual results will be over and under the estimate (base or funded), along with the confidence interval that these percentages represent.

TABLE 1. AACEI ESTIMATE CLASSES, DELIVERABLE STATUS AND RANGE-OF-RANGES

		Range of ranges	
AACE Class	Key deliverable status	Low end (p10)	High end (p90)
Class 5	Block flow agreed upon by stakeholders	–50 to –20%	+30 to +100%
Class 4	Process flow diagrams issued for design	–30 to –15%	+20 to +50%
Class 3	Process and instrumentation diagrams issued for design	–20 to –10%	+10 to +30%
Class 2	All specifications and datasheets complete	–15 to –5%	+5 to +15%
Class 1	Most or all engineering and design work complete	–10 to –3%	+3 to +15%

Estimation accuracy

A capital cost estimate is expressed as a range of possible costs, rather than a discrete "number." Effective cost estimators work to understand (and be honest about) the details and factors that they do not know. Those preparing estimates must communicate the project risks, the range of possible outcomes and, most importantly, how those two go together.

Accuracy ranges are expressed as low and high percentages that form a boundary around the expectation of how final actual costs will differ from the estimate. For example, a range of +30%/–10% tells management that the final costs may be as much as 30% more or 10% less than the estimate after taking into account all of the identified risks. To be complete, range statements should inlcude the confidence in the range. (for instance, stating that 80% of the time, the project will be within these bounds). It is also important to specify the reference point upon which the range is based (it can be relative to the base estimate or to the funded amount, including contingency).

Scope definition and risk

The level of scope definition is the greatest driver of cost uncertainty. Estimate accuracy improves with the level of scope definition. Since the 1990s, almost every major CPI owner company has implemented a phase-gate project system, and the phases usually line up with the Association for the Advancement of Cost Engineering (AACE) International (Morgantown, W.Va.; www.aacei.org) AACE Estimate Classes (Table 1). Other key risk drivers within the project scope include the introduction of new technology into the process and the level of complexity in the physical system, as well as the execution strategy.

Bias

Capital project management is a realm of intense cost pressures and biases. If high estimates scuttle project sanction, the estimator's performance rating and career development may be put at risk. In slow economic times, cancellation of a large project may mean the loss of the team's jobs. For decision makers, optimism bias often prevails. For many reasons, the desire and pressures to make a "go-ahead" project decision can be immense. The more strategic the project, the more these biases create pressure for lower cost estimates, resulting in discrepancies. On the other hand, overruns may be punished, and this drives conservative estimating practices by those afflicted, particularly in small project systems.

These biases and their effect on estimating behavior are major sources of cost uncertainty. If the bias is toward decreased base estimates, more contingency will be required, and vice-versa if the bias is toward increased base estimates. ■

Editor's note: This column is based on information found in Hollman, J., Improve Your Contingency Estimates for More Realistic Project Budgets, *Chem. Eng.*, December 2014, pp. 36–43.

Polypropylene Carbonate Production

By Intratec Solutions

Polypropylene carbonate (PPC) is a thermoplastic polymer produced from the catalyzed copolymerization of carbon dioxide (CO_2) and propylene oxide. The copolymer chain is composed of alternating segments of CO_2 and propylene oxide, along with small amounts of propylene oxide homopolymer. Some of its important properties include excellent transparency, good barrier to water and oxygen, printability and nontoxicity.

PPC offers important environmental advantages: it acts as a sequester for CO_2, which can help minimize the impact of global warming, and some PPC composites are designated as biodegradable materials.

The process

The present analysis discusses an industrial process for PPC production comprising four major sections: (1) polymerization; (2) phase separation; (3) monomer separation; and (4) pelletizing and finishing (Figure 1).

Polymerization. Fresh CO_2 feed is mixed with recycled CO_2 from the monomers separation stage. Propylene oxide feed is also mixed with a recovered stream. Both reactants are treated for moisture removal. Part of the treated propylene oxide feed is introduced to the polymerization reactor outlet to dissolve the polymer solution obtained in the reactor. The remainder is mixed with catalyst and CO_2 feed, forming a liquid solution that is transferred to the prepolymerization reactor. The prepolymerization reaction effluent is fed to the polymerization reactor, where the polymer solution is obtained.

Phase separation. The polymer solution is contacted with a material that binds to the catalyst and allows its removal via filtration. The catalyst-free solution is subjected to gradual pressure decrease, so that unreacted monomers can be released. Once unreacted monomers are removed, the polymer melt is transferred to the pelletizing and finishing stage, while released monomers are routed to the monomers separation area.

Monomer separation. Unreacted monomers are fed to two consecutive distillation columns, from which three streams are obtained. A high-purity propylene oxide stream is recycled to the feed preparation step and mixed with fresh feed. A carbon-dioxide-rich stream (also containing propylene oxide) is also recycled to feed preparation. Another stream, comprising heavy ends generated as side-products, is discharged from the process.

Pelletizing and finishing. The polymer melt is fed to a pelletizing system, where it is homogenized and pelletized. Subsequently, the pellets are packed in bags before being stored in warehouses.

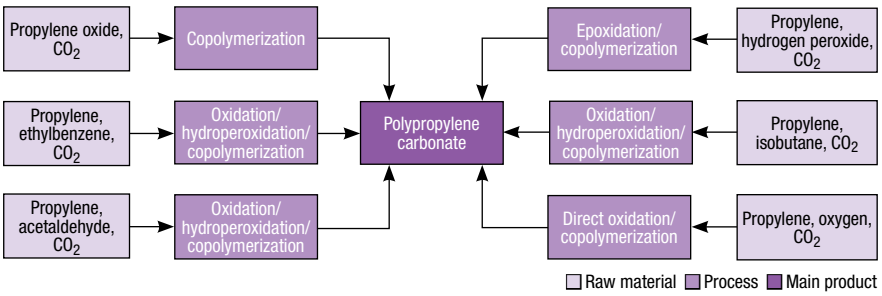

FIGURE 2. Multiple pathways exist for the production of polypropylene carbonate

Production pathways

Commercial production of PPC involves the catalyzed copolymerization between carbon dioxide and propylene oxide, in such a way that different manufacturing routes are related to different sources of these raw materials. Figure 2 illustrates PPC production pathways.

Economic performance

The total operating cost (raw materials, utilities, fixed costs and depreciation costs) estimated to produce PPC was about $1,660 per ton of PPC in the third quarter of 2016. The analysis was based on a plant constructed in the U.S. with the capacity to produce 20,000 metric ton per year of PPC.

This column is based on "Polypropylene Carbonate Production – Cost Analysis," a report published by Intratec. It can be found at: www.intratec.us/analysis/polypropylene-carbonate-production-cost. ■

Edited by Scott Jenkins

Editor's note: The content for this column is supplied by Intratec Solutions LLC (Houston; www.intratec.us) and edited by *Chemical Engineering*. The analyses and models presented are prepared on the basis of publicly available and non-confidential information. The content represents the opinions of Intratec only. More information about the methodology for preparing analysis can be found, along with terms of use, at www.intratec.us/che.

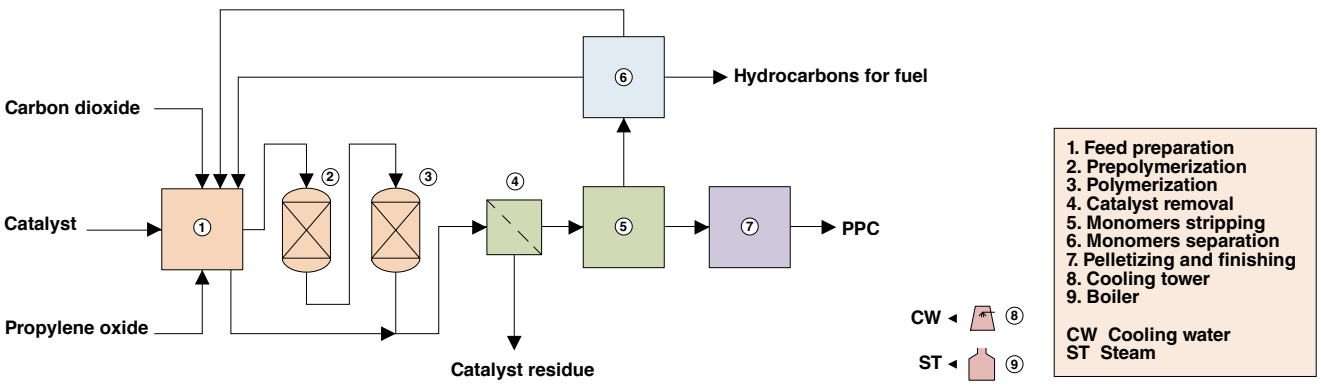

FIGURE 1. The diagram shows the production of PPC from propylene oxide and CO_2

Electrolyzer Technologies for Green Hydrogen

Hydrogen is poised to be a cornerstone of the global energy transition and its production via electrolysis has ignited demand for high-performance electrolyzer units

Technological and economic advances have brought hydrogen to the forefront of sustainability strategies in many industries, with end users hoping to capitalize on the promise of significantly reducing, or altogether eliminating, CO_2 emissions.

Electrolyzer basics

Much of the activity surrounding hydrogen today involves electrolyzers, which are modular processing units wherein electrical current is applied to split water molecules into hydrogen and oxygen. When powered by renewable electricity sources, such as wind or solar power, electrolyzers produce emissions-free, or "green" H_2.

In recent years, production of electrolyzers has ramped up significantly to meet global demand for green H_2. In June, thyssenkrupp Industrial Solutions AG (Essen, Germany; www.thyssenkrupp-industrial-solutions.com), in partnership with De Nora S.p.A. (Milan, Italy; www.denora.com), expanded its manufacturing capacity for electrolyzer units (Figure 1). "We now have the capability to build electrolysis plants with an annual capacity of 1 gigawatt, and we will expand our capacities even further," explains Christoph Noeres, head of energy storage and hydrogen at thyssenkrupp. These electrolyzers are offered as prefabricated skid-mounted modules (Figure 2), which can be combined to easily scale up production capacity. Scaling up the electrolyzer capacities, says Noeres, will help to realize economically promising value chains, not just for the large-scale production of green H_2, but also for the subsequent manufacture of sustainable chemicals, such as ammonia and methanol. "Green H_2 will play a central role in achieving greenhouse-gas neutrality, as well as the establishment of a closed-loop economy," adds Noeres. On the horizon, thyssenkrupp is focusing its development projects on regions with favorable conditions for power-to-x applications. Earlier this year, the company announced that its electrolysis plants will be able to link to the German electricity market via E.ON's virtual power plant, effectively acting as large-scale buffers to stabilize the power grid. For this ambitious milestone, the electrolyzers had to meet several load-change qualification criteria detailed in the grid codes of transmission operators, demonstrating that they exhibit sufficient response speed and flexibility to participate in the energy-balancing market.

There are two primary types of electrolyzers on the market — alkaline and proton-exchange membrane (PEM). Other emerging electrolysis technologies, which are still primarily in the development phase, include anion exchange membrane (AEM), solid-oxide electrolyzer cell (SOEC) and photo-electrochemical (PEC) water splitting. In an alkaline electrolyzer, the water is split into its constituents in the presence of a caustic electrolyte solution

FIGURE 1. Electrolyzer manufacturers are expanding capacity to satisfy growing global demand

— frequently potassium hydroxide (KOH). The water-splitting reaction in a PEM electrolyzer gleans its electrolytes from a catalyst that is applied to a polymeric membrane.

Alkaline electrolysis is the more established technology, and alkaline electrolyzers typically are more affordable, but PEM electrolyzers bring some added value via a more rapid response to changes in power. Furthermore, PEMs are often seen as a safer option, since the membrane provides a physical barrier between the produced H_2 and O_2.

Lower costs, higher performance

Although electrolyzers are not new, recent development work and industry trends have made them much more attractive when compared to conventional H_2 production from natural gas via steam-methane reforming (SMR), says David Bow, senior vice president, corporate business development & strategy, Nel Hydrogen (Wallingford, Conn.; www.nelhydrogen.com). "The electrolyzer industry has dropped its capital costs by as much as 75%

in the past 2 to 3 years, which has been driven mainly by market need for larger systems and innovation in system design and manufacturing," explains Bow. The proliferation of low-cost renewable energy is also an enormous driving force, alongside pressure to meet corporate and government sustainability targets. "An SMR will produce 10 to 12 tons of CO_2 per ton of H_2 produced. Now, low-cost renewable electricity can be supplied to make green H_2 with zero CO_2 emissions," says Bow. A major goal for electrolyzer providers is to achieve "fossil parity" — meaning the electroyzer can produce green H_2 for the same price as using an SMR with natural gas ("gray" hydrogen).

After achieving considerable cost reductions, Nel is now focusing more of its developmental efforts into improving electrolyzer efficiency and performance, including work to decrease the amount of precious metals (like platinum and iridium) in PEM catalysts, and advancements in electrode technology for alkaline systems.

Geography is an important factor when comparing the economy of SMRs with electrolyzers. In some areas, where natural gas feedstock for SMR units is scarce, natural gas needs to be shipped; or H_2 transported via tube trailers or in liquid form in tank trucks, which is very inefficient and CO_2-intensive. "Since H_2 is such a light molecule, a full tube trailer truck can carry only around 350 kg. Furthermore, there are considerable losses when storing hydrogen as a liquid, since it vents off as temperatures change," explains Bow. This makes onsite generation of H_2 a much more attractive proposition for major hydrogen consumers, such as ammonia plants, methanol plants and petroleum refineries.

While SMRs are by far the dominant technology, many chemical processing sites are turning to electrolyzers to help augment SMR capacity and increase plant flexibility, since electrolyzers can operate efficiently over a large turndown ratio and are readily scalable. Bow mentions an example of a large chemical manufacturer who was purchasing H_2 from a nearby SMR unit and found that their demand had outgrown the SMR's capacity. "They looked at buying another SMR unit versus transitioning to electrolyzers or transporting liquid H_2 in tanker trucks and found that electrolyzers in series provide more efficiency at a lower cost," says Bow.

FIGURE 2. Their modular nature makes electrolyzers suitable for installations both large and small

FIGURE 3. These compact electrolyzer units are designed for installation in challenging locations, such as the head of a wind turbine, for streamlined energy storage

Nel has undertaken a variety of pilot-scale tests for different H_2 applications, helping sites to transition from gray to green H_2. "Many, if not all, major ammonia producers are looking at some level of electrolysis testing. We have a wind-to-ammonia project in Minnesota that has been running for several years and many more in the pipeline. We've also sold a number of large-scale alkaline electrolyzers for production of ethylene and sugar alcohols, both of which consume large amounts of H_2 in the process," says Bow.

Nel Hydrogen is one of several recipients of funding under the H2@Scale initiative funded by the U.S. Department of Energy (DOE; Washington, D.C.; www.doe.gov), through the Office of Energy Efficiency and Renewable Energy's (EERE) Hydrogen and Fuel Cell Technologies Office (HFTO). In July, $64 million in funding was awarded to 18 projects supporting H2@Scale's goals of advancing the U.S. hydrogen economy. Nearly $15 million of the most recent round of funding went to projects focused specifically on manufacturing electrolyzers. "An advantage of electrolyzers is their suitability with intermittent renewable-power sources, such as wind and solar. Instead of curtailing power, electrolyzers can be used to make H_2 for either energy storage or for other value-added end-use applications, such as manufacturing chemicals or steel," explains HFTO director Sunita Satyapal.

For electrolyzers, H2@Scale's main goals involve improving efficiency and durability while reducing overall costs. As electrolyzer technologies have progressed, Satyapal points out a trend toward more holistic and collaborative development projects. "Instead of looking at specific components, like catalysts or membranes, much of the current work deals with the integration of materials and manufacturing processes, and how we might be able to integrate them to be manufacturable at scale," she says. "An example of a unique area we have been funding is quality-control methods. Ideally, if we are going to ramp up electrolyzers to gigawatt scale, the components wouldn't be manufactured in batch processes, so we are looking at higher-throughput continuous processes, such as roll-to-roll, as well as high-speed inspection over large-

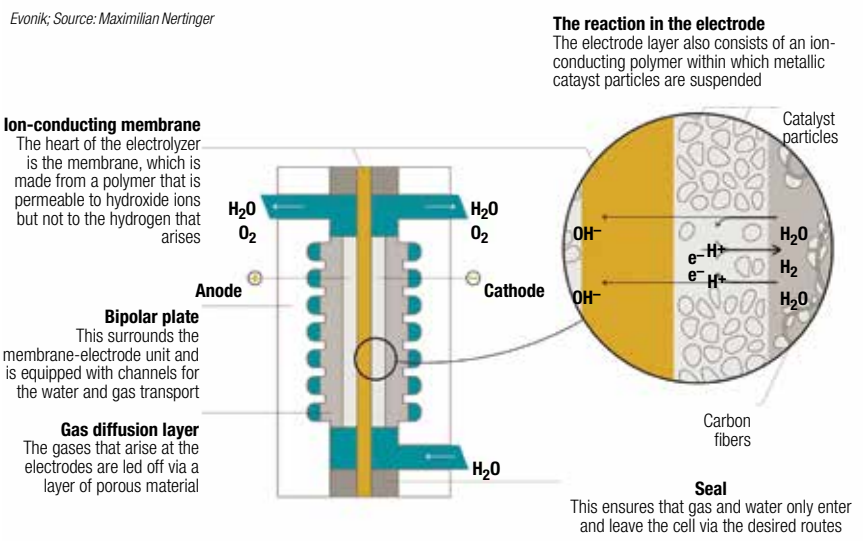

FIGURE 4. AEM electrolyzers are poised to combine the benefits of alkaline and PEM electrolyzers, which are currently the dominant technologies on the market

area components to find defects that could impact durability." Some of the other major areas of development include: membrane-coating techniques and simplifying membrane fabrication; optimizing the porous transport layer; and reducing precious-metals content. In addition, H2@Scale is working on two first-of-their-kind nuclear-to-H_2 projects in the U.S.

H2@Scale is focusing on multiple hydrogen production, storage, distribution and utilization needs, including PEM electrolyzers, which are gaining traction in the market, but still have potential for major cost reductions. Feedwater quality is another emerging area of research for the project, says Satyapal. "We have a few early-stage projects investigating the ability to use dirty water or salt water, as opposed to requiring high-purity water for electrolysis," she adds. "We also have a first-of-its-kind project in the U.S. where we are producing H_2 with an electrolyzer and using a biological system to make renewable methane with H_2 and CO_2," says Satyapal.

Synergy with natural gas is another area with significant interest, specifically in blending H_2 and natural gas, with the potential to inject hydrogen into natural-gas pipelines. However, with H_2 blending, materials compatibility can be a major concern depending on materials used, and much research activity involves the effects of hydrogen on embrittlement and its impact on both metals and polymers, as addressed by DOE's H-Mat consortium.

A significant milestone in H_2 blending took place in July, when Baker Hughes (Houston; www.bakerhughes.com) and Snam (San Donato Milanese, Italy; www.snam.it) completed testing of the world's first "hybrid" hydrogen turbine designed for a gas network, with the ultimate goal of injecting H_2 blended with natural gas into Snam's current transmission infrastructure.

Advancing PEM electrolysis

Hoeller Electrolyzer GmbH (Wismar, Germany; www.hoeller-electrolyzer.com) has developed an optimized cell-surface technology for compact PEM electrolyzers (Figure 3) that reduces the amount of precious metals required and increases operating pressure. Hoeller is designing its PEM cell stacks with demanding installations in mind, such as integrating the stack directly into the head of a wind turbine. "The key advantage of PEM electrolysis is that the H_2 production almost instantaneously changes with the energy provided, so processes with a changing need for H_2 are an ideal match," says Matthias Kramer, chief financial officer at Hoeller. According to Hoeller, its stacks can handle load changes from 0 to 100% of nominal load within seconds. While PEM is versatile in the face of shifting demand, Kramer also emphasizes its ability to operate continuously. Furthermore, the stack is capable of pressurization to 50 bars or higher, making direct

Frames Group

FIGURE 5. A molecular sieve unit may be installed downstream of an electrolyzer for dehydration purposes

storage more convenient. Hoeller's proprietary PEM technology was demonstrated in a proof-of-concept at the Fraunhofer Institute for Solar Energy Systems (ISE; Freiburg im Breisgau, Germany; www.ise.fraunhofer.de), and Kramer says that the company expects to install a prototype unit by the end of 2020. Discussions are also in place regarding a pilot project for the new PEM stacks at a wind farm in Schleswig-Holstein, Germany.

AEM electrolysis

One emerging technology for H_2 production is anion-exchange membrane (AEM) electrolysis (Figure 4). AEM is somewhat of a hybrid solution combining the benefits of PEM and traditional diaphragm-based alkaline electrolysis, explains Oliver Conradi, who specializes in membrane research at Evonik Industries AG (Essen, Germany; www.evonik.com). "Alkaline electrolysis obviously involves very basic conditions, while PEM involves an acidic environment. These respective pH values require certain materials. In alkaline conditions, you can use cheaper materials, such as stainless steel and nickel, whereas with PEM, you must use platinum or other precious metals for the catalyst, and the electrochemical cell must be based on titanium, so the investment cost for PEM is much higher," explains Conradi. However, PEM systems overcome some of the fundamental limitations of traditional alkaline electrolysis — due to the specific cell design in alkaline systems, current density and efficiency are limited, and it is more difficult to pressurize an alkaline system, meaning that an additional compression step is typically required. "In PEM units, the dense membrane makes it easier to pressurize the whole system. With AEM, you can fundamentally combine the advantages of both state-of-the-art technologies, while you compensate for their drawbacks," says Conradi, noting that the primary hurdle in developing an effective AEM system is developing a suitable polymeric membrane material that can withstand alkaline conditions.

A particular area of focus is on the cationic moiety, which is responsible for transporting the hydroxide ions from the cathode to the anode. In addition to stability in an alkaline environment, the polymer must also provide high ion conductivity and stability under pressurized electrolyzer conditions. Inspired by an existing membrane technology for gas separation, Evonik has developed a new polymer chemistry featuring a proprietary ion-conducting cationic moiety. As part of the AEM-focused Channel consortium, Evonik is expanding production of the polymer and also scaling up membrane fabrication on a pilot coating line. "The consortium is building an AEM electrolyzer to demonstrate that the membrane and other components work under challenging conditions," explains Conradi. The group's first AEM demonstrator unit is at the laboratory scale, where test protocols are being run to reflect real-world conditions. "The next milestones will be proving system reliability and scaling up the stack sizes, while also scaling up membrane processing," he continues.

Downstream H_2 processing

Although electrolyzers have made strides in efficiency and cost, the produced H_2 still often requires post-processing steps, such as compression, dehydration or purification. "Electrolysis stacks usually do not produce hydrogen that is directly suitable for use. If you want to store, distribute or utilize the produced hydrogen, contaminants need to be removed," says Jordi Zonneveld, manager of the hydrogen portfolio at Frames Group (Alphen aan den Rijn, the Netherlands; www.frames-group.com). "Since PEM technology uses only ultra-pure water, the only contaminant is water, and potentially a very small amount of oxygen. Alkaline electrolysis uses a KOH solution as the process fluid, and therefore traces of KOH in the produced hydrogen need to be removed, as well."

Depending on the gas flow and purity requirements, there are several steps that may be required to prepare H_2 for its end-use applications. For instance, says Zonneveld, knock-out drums with demisting internals and optional gas-cooling equipment are generally used as a first step to bring hydrogen purity up to 99.9%. Then, if higher purity is required, a molecular-sieve unit (Figure 5) may be required. He also mentions that dehydration using triethylene glycol — a common technology for natural-gas processing — has shown potential for H_2 purification, but there have not yet been any large-scale H_2 applications.

Compression of H_2 also introduces unique challenges. "H_2 has a very high energy density per mass, but a very low density, so compressors are needed downstream of electrolyzers to compress the H_2 for efficient storage and transportation," says Stefanie Peters, managing partner at Neuman & Esser Group (NEA; Übach-Palenberg, Germany; www.neuman-esser.de). The low molecular weight of H_2 also poses issues. "Turbomachinery faces significant problems in capturing the H_2 in the compression chamber, and only positive-displacement machinery like piston and diaphragm compressors are suitable for efficient compression to required H_2 discharge pressures," add Peters. For instance, dry-running piston compressors can achieve discharge pressures up to 300 bar. When equipped with lubricated cylinders, the discharge pressures are potentially as high as 700 bar, but this option introduces trace amounts of oil contamination, so in cases where no contamination is acceptable, oil-free diaphragm compressors are the preferred high-pressure option, as they can achieve more than 5,000 bar discharge pressure.

As the demand for electrolyzers and green H_2 continues to grow, technological improvements, not just in the electrolyzers themselves, but also in post-processing, will continue to be vital areas of research and development work. ■

Mary Page Bailey

A Holistic Approach for Pump-System Analytics

A step-by-step approach is presented to address the modern requirements of a pump-system digital solution

Stylianos Giannoulakis
Sulzer Management Ltd.

In recent years, significant developments have been achieved in the fields of cloud computing and machine learning techniques. In conjunction with increased awareness regarding the benefits of digital transformation, from both users and manufacturers of industrial equipment, a unique opportunity is emerging. This article describes a comprehensive solution for addressing pump system monitoring, and predictive and optimization analytics in a holistic manner. The target of the proposed approach is to leverage all available system data and infrastructure and to address issues of traditional monitoring solutions. Typically, traditional performance monitoring and predictive solutions are simply accepting errors of raw sensor data or modeling assumptions, or both. In addition, any reliability alerts are based on thresholds of individual sensors, which are usually triggered at the time of failure, providing no reaction time to the user.

As shown in Figure 1, five distinct steps are defined as part of an integrated solution: 1) connect remote industrial equipment to the internet; 2) monitor the state of the equipment; 3) analyze the operating conditions; 4) predict the behavior of individual components and of the complete system by training customized models; and 5) optimize a pump system at the aspects of performance efficiency, reliability and profitability. This article presents the background of the successful deployment of the first three steps to a major pipeline operator, along with the current research and development efforts to cover the remaining two steps.

Connectivity

Different connectivity options are available today, however the preferred solution will exploit existing infrastructure. Typically, most pump systems of medium or high criticality are equipped with a certain number of permanent sensors, registering values of fluid volumetric flow, pressures, density, pump status, vibrations, temperatures and driver energy consumption. All sensor values are stored in a central local database and can be accessed by the operator. The proposed solution extends the process by fetching all required values from the local database and transferring it to a cloud solution (Figure 2). This approach leverages existing infrastructure, does not disrupt existing operations and delivers all necessary data to a cloud environment, which offers global access to multiple users and leverages modern techniques of cloud computing.

Raw sensor data are averaged for a short pre-defined time interval (typically in the range of a few minutes) and a selection of monitored parameters are concentrated into a file, which is subsequently pushed to a secure cloud service. The data transfer is only one way, enabling the user to push the required data, but at the same time ensuring that no access is possible through the firewall. Each file pushed from the user includes sensor values as a representation of the equipment's operating conditions for a discrete timestamp. All

FIGURE 1. Visual representation of a step-by-step approach for pump system analytics

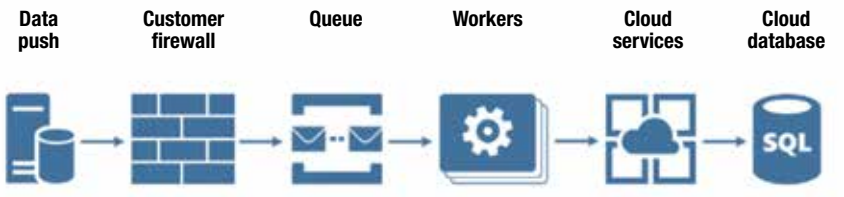

FIGURE 2. This diagram shows the automated data flow of asset-sensor values to the cloud infrastructure for further evaluation

data files end up at the cloud landing zone, where they are queued for the first levels of pre-processing. A selection process takes place ensuring proper sequencing of data according to their timestamps. Other standardization layers ensure that data are converted into default units of measure and they are structured to a relational database. The data are structured following the relations and topology of physical equipment. More details on the topic of equipment topology are provided below.

Analytics architecture

This section discusses the overall data flows and analytics algorithms, providing a better understanding of the targeted architecture, which is shown in Figure 3.

Following the standardization path of the previous section, for every new timestamp, raw sensor values are stored in the cloud database. Apart from operational data, static information is also stored in the same database, which characterizes the different components of the physical process. Such model parameters define the nominal expected behavior of the equipment.

The first step of the process is to evaluate the collected data for every timestamp. Targeting to minimize both the measurement errors and the model uncertainties, a data-reconciliation method is employed. Such a method leverages conservation equations and component modeling, to correct both measurement values and model parameters. The adapted values are stored back to the database and they will be the basis of all downstream calculations.

After establishing the monitoring calculation, the user can assess the impact of the validated operating conditions of the asset along with the deviation of corrected model parameters by comparison to the nominal ones. The latter can provide insights

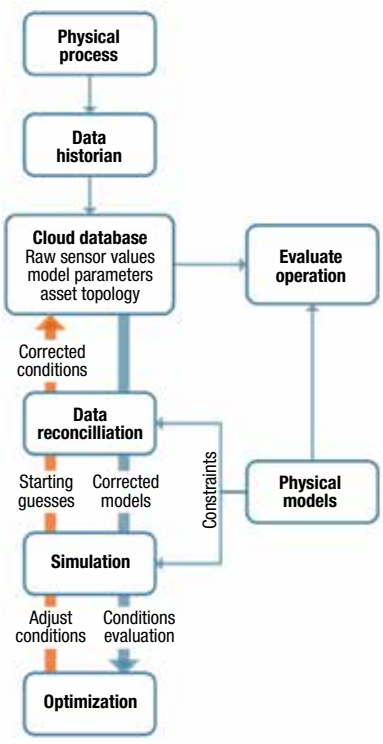

FIGURE 3. Shown here is an overview of data flows and analytics algorithms

on degradation patterns over time.

Corrected model parameters of recent operation are used to simulate the performance of the pump system. Instead of relying on theoretical values, the system performance is estimated based on the latest measurements. Last but not least, an optimization engine triggers simulations, to identify the optimal operating conditions satisfying the user's requirements for overall system performance.

Downstream calculations are also leveraging the monitoring results. Deviations from the pump's best efficiency point (BEP) provide insights to both performance losses and accumulated impact on the pump's reliability. Finally, machine learning algorithms are employed to identify abnormalities in pump operation and to notify the user in case of an imminent failure.

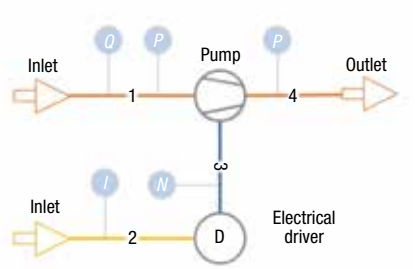

FIGURE 4. This diagram shows a pump/electrical-driver system with measurements for volumetric flow (*Q*), pressure (*P*), suction, discharge, rotational speed (*N*) and electrical current (*I*)

From monitoring to analytics

Following a digital-twin monitoring approach, a physical representation of the system (in addition to the sensor data) is required. Input shall be provided concerning the system topology, along with technical characteristics of the individual assets (that is, pumps, drivers, couplings, pipes, valves, sensors and so on). The combination of operational data and system characteristics offers the basis for pump-system monitoring. In a traditional monitoring system, every component is evaluated based on nearby sensor measurements and the overall performance of the system by using a subset of the local sensors. In the proposed approach, local raw measurements are combined with equipment topology and modeling. This strategy enriches the available sensor data, imposing physical and numerical constraints to the solution.

In detail, a steady-state network flow approach is followed to construct the analyzed pumping system. System equipment (pump, pipe, valve, electrical driver and so on) are represented as system nodes and pre-defined physical equations describe their behavior. The combination of these nodes can represent complex pumping configurations. During the digital-twin configuration, node combinations define the asset topology. Furthermore, a number of model parameters need to be speci-

TABLE 1. MEASUREMENT AND MODEL ADAPTATION RESULTS FOR SAMPLE PUMP

Variable	Unit	Raw	Adapted	Δ	Confidence
Q_1	m^3/s	0.120	0.121	0.83%	95%
P_1	kPa	100	100	–0.04%	95%
I_2	A	117.0	116.1	–0.77%	95%
N_3	rpm	3,580	3,580	0.00%	95%
P_4	kPa	2,600	2,626	1.00%	95%
Δ *Efficiency*[1]	–	1.0	0.824	–17.60%	80%
Δ *Head*[1]	–	1.0	0.945	–5.50%	80%

1 (superscript) model parameters correcting the nominal pump performance (efficiency and head coefficient)

fied to describe the nominal performance of the specific equipment. All required topology and model parameters are stored in a central cloud database to be accessible by the analytics algorithms.

Both process data and equipment modeling suffer from some degree of error, either random or systematic. A data-reconciliation method is applied, inspired by applications in chemical and power plants [*1*]. Such methods are able to evaluate non-linear models of equipment. They rely on data redundancies (that is, sensor values, equipment topology and physical equations), to optimally adjust measured quantities and model parameters by respecting problem constraints and conservation equations. This method derives the most probable operating conditions of both the complete system and of individual components (pumps, motors, pipes, valves and so on). This global approach reduces the level of uncertainty for every evaluated timestamp and derives customized component characteristics according to the latest status of the equipment. Any general data reconciliation procedure must solve the following constrained least-squares problem; that is, to minimize Equation (1) subject to the constraint of Equation (2):

Minimize:

$$J(\hat{y},\hat{z}) = (y-\hat{y})^T V^{-1} (y-\hat{y}) \quad (1)$$

Subject to:

$$A_y \hat{y} + A_z \hat{z} = 0 \quad (2)$$

Where, y and z are the raw measured and non-measured parameters, $\hat{y}$ and $\hat{z}$ are the adapted parameters respectively, A is the incident and V the variance matrices.

A simplified example is shown in Figure 4, where a number of measurements are available for a pump/electrical driver system. One can also take into account the physical modeling equations that describe the expected behavior of the system. In such a case, an overdetermined system is derived, where measurements will not fit the nominal expected behavior of the components. A data-reconciliation method is applied and Table 1 illustrates the corresponding results. It is noted that depending on the amount of confidence given to measurements and model parameters, the adaptation results can vary. In this example, higher confidence is given to measured values and lower to model parameters,

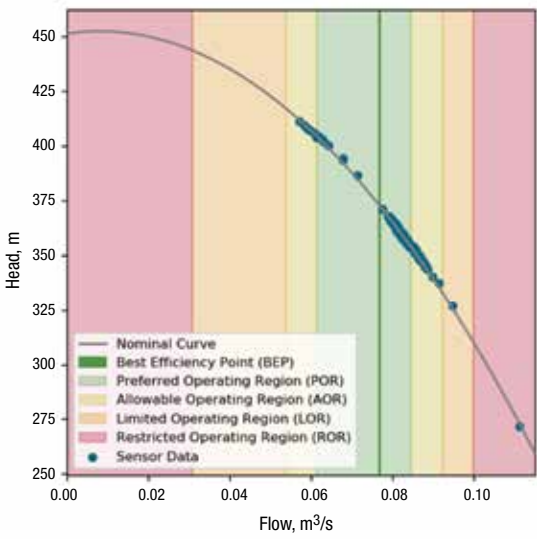

FIGURE 5. This graph shows the comparison between sensor data and the nominal curve and recommended operating regions

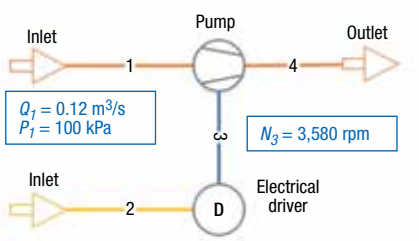

FIGURE 6. This diagram shows a pump/electrical-driver system with volumetric flow (*Q*), suction pressure (*P*) and rotational speed (*N*) as system boundary conditions

TABLE 2. SIMULATION PARAMETERS FOR SAMPLE PUMP – ELECTRICAL DRIVER SYSTEM

Variable	Unit	Nominal	Degradation	Type
Q_1	m^3/s	0.120	0.120	Condition
P_1	kPa	100	100	Condition
I_2	A	100.18	114.94	Result
N_3	rpm	3,580	3,580	Condition
N_{p3}	kW	383.2	439.7	Result
Q_4	m^3/s	0.120	0.120	Result
P_4	kPa	2,789	2,642	Result

which corresponds to higher adaptations for the model parameters. Moreover, the sensor data of the evaluated timestamp, indicate that the pump performance is deviating (18% for efficiency and 5% for head) from the nominal expected behavior. Increasing deviation over time can be an indication of performance degradation.

Additional constraints can be added to the system, by increasing the number of available sensors and the complexity of the pumping system. This leads to a problem closer to the scale of modern pumping systems and data reconciliation is proven an appropriate method for reducing measurement and model uncertainties.

Every timestamp is evaluated following the above methodology, and this offers greater confidence on the collected data set for analysis. The analysis step will provide a clear picture of the current and historical operation of every pump and the rest of the equipment. For every component, the validated operating conditions can be compared to the nominal and preferred operation. Either by using API or a vendor's recommended zones, pump operation will be evaluated. A visual comparison between real operating data and recommended operating regions is shown in Figure 5.

Conclusions can be drawn concerning the equipment's performance and reliability status. Not only performance, but also the pump's reliability are influenced by deviating from best efficiency point (BEP) flowrate, for example through the damaging effects of part load recirculation [2]. The impact of historical operation can be analyzed, providing insights on operational improvements.

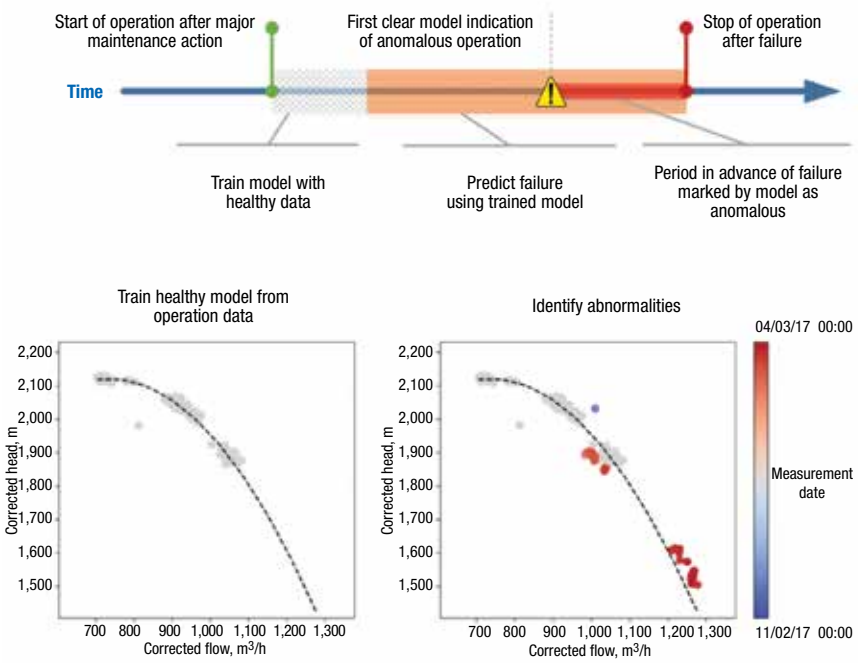

FIGURE 7. The sequence at the top shown how an unsupervised machine-learning anomaly-detection algorithm works over time. The benchmark model is trained from healthy data (graph, lower left), which can then be used to identify operational abnormalities (graph, lower right)

Performance and reliability

Greater financial value for the user can be achieved when predictions are made concerning the future equipment operation. Performance predictions can offer significant insights about the system capabilities. The user is able to test different operational scenarios and assess their impact. This can improve the scheduling of future operation and match demand with supply requirements more accurately. The proposed solution offers performance predictions for pump systems by leveraging the derived customized equipment characteristics, as described in the previous paragraph. In combination with the system topology and specified boundary conditions, the user shall trigger simulations to derive the operating conditions of individual components and of the complete system. The simulation process involves the complete pump system calculation and the final solution shall fulfill all physical modeling equations.

As in the previous section, a simulation example of a simplified pump/electrical driver system is shown in Figure 6 and the corresponding results in Table 2. Comparison results are provided by both using the nominal pump-performance characteristics and by applying the degradation factors, as calculated in the previous section. As expected in comparison to nominal behavior, the pump discharge pressure is decreased, whereas the power con-

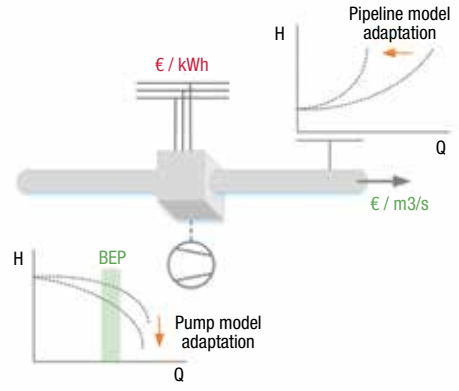

FIGURE 8. Shown here is a multiple-target optimization problem of a pump system. Underlying performance models are adapted to represent latest equipment behavior

data reconciliation, where an overdetermined system is resolved, in simulation, the number of unknowns matches exactly the available equations. This requirement dictates the necessary number of parameters that need to be specified in advance as system boundary conditions (in this example, it is equal to three). An approach for solving nonlinear equations is employed [*3*], by iteratively solving a system of linear equations:

Solve per iteration:

$$A_z \cdot \delta z = -F \quad (3)$$

Apply corrections:

$$\hat{z} = z + \delta z \quad (4)$$

Where, z are the original unknown parameters and $\hat{z}$ are the calculated parameters by applying the respective corrections δz, A_Z is the Jacobian and F the residual matrices.

Following the proposed methodology, complex pump systems can be simulated. Where the performance characteristics of each component shall be adapted in advance, according to recent sensor values and data reconciliation results. This approach offers a great number of what-if scenarios for evaluating the current performance of the pump system. The operator shall test the operating requirements by performing system simulations, reflecting the different operating scenarios available. Due to the nature of the approach, boundary parameters can be specified according to the desired operating conditions. In case the throughput is of major interest, the volumetric flow is provided as a boundary condition and the system should resolve the other parameters. Similarly, if discharge head or pump operation close to BEP are of interest, these are defined as boundary conditions.

Concerning reliability predictions, the target of the proposed approach alerts the user with sufficient notice, in order to prevent an imminent failure. A clear benefit is gained through applying corrective measures before the failure even occurs. It can reduce

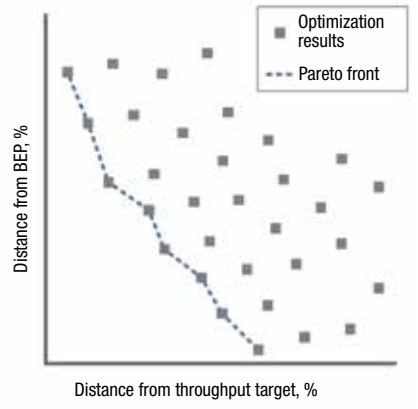

FIGURE 9. Shown here is a pareto front between two competing targets of a pipeline system

the number of catastrophic failures, which have a significant impact on repair costs and downtimes. To achieve this reliability goal, machine-learning techniques are employed. More precisely, a combination of unsupervised anomaly detection with pump-physics-driven modeling is selected. While the specificity of anomaly detection techniques can be inadequate, the problem space may be reduced considerably by imposing constraints on variables, especially by modeling the correlations between components [*4*].

The target is to determine if a pump is operating according to normal operation standards or abnormality evidence is indicating an imminent failure. For that reason, the training data are used to learn a model of the normal behavior. When doing inference, new data are compared to the expectation and then classified. A review of common such methods can be found in Ref. 5. As seen in Figure 7, after every major maintenance action of the pump, a model representing the healthy asset is trained, which is used as the benchmark model for any future operation. Such models shall represent the pump healthy operation at the full range of operating conditions. For every new timestamp available, the pump conditions are compared to the healthy benchmark model and every deviation and abnormality is a potential indication of a developing issue.

The key point of the proposed solution is that such a method does not rely on individual sensors' threshold values. Instead, multiple sensors are combined together, pump key performance indicators are evaluated and compared to their expected value. In several cases, this approach can provide an indication of the developing issue much earlier than the traditional threshold-monitoring approach. The latter usually triggers an alert only seconds before the actual failure.

Optimization capabilities

By establishing performance and reliability predictions, the next target of this solution is to offer optimization capabilities to the user. An optimizer shall trigger simulations of the pump system and based on an optimization strategy and boundary conditions, the operation can be optimized for single or multiple targets. The pump system performance can be optimized, by ensuring the minimum energy is consumed for given load requirements. Another target can be the operation shift close to preferred conditions, achieving also maximization of the reliability index. Furthermore, the use of drag-reducing agents can be optimized, by ensuring at the same time that the pump system will operate at the desired conditions. It is apparent that all discussed optimization strategies also have a positive impact on the financial targets of the system operation.

An optimization example is shown in Figure 8, where competing targets are illustrated. A typical target of a pipeline operator is throughput maximization. In addition, any reduction in operational costs (that is, electricity or fuel consumption) is of great interest. Last but not least, ideally all pumps shall operate as close as possible to their BEP, to ensure performance and reliability benefits. Based on the established data reconciliation method, physical pump and pipeline models are adapted to represent the current equipment behavior.

In the proposed approach, an optimization method shall set the boundary conditions and trigger simulations of the pump system digital twin. The optimizer shall evaluate the simulation results and classify them according to the predefined target or targets. Several simulation optimization methods are available in the literature (for instance, gradient-based search, heuristic methods and so on), a critical review of available methods is presented in Ref. 6.

An example of the expected optimization results is shown in Figure 9. In case of two competing targets (that is, maximum system throughput and pump operation at BEP), a number of optimal solutions formulate a pareto front. The algorithm offers a number of viable solutions to the operator to choose from. ■

Edited by Gerald Ondrey

Note

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Designing an Integrated Wastewater-Treatment System

Meeting the wastewater-treatment demands of an integrated manufacturing complex demands a design that can address a diverse array of contaminants and discharge requirements

Brian Arntsen
SUEZ Water Technologies & Solutions

IN BRIEF

Any large, integrated chemical-manufacturing complex will require the implementation of a comprehensive wastewater-treatment solution to address unique wastewater challenges and comply with all necessary effluent discharge requirements. This article outlines the process for designing and commissioning such a wastewater-treatment facility, using real-life examples from Sasol's new chemical-production plant in Westlake, La., near Lake Charles. The facility produces liquid fuels from coal, and includes a 1.5-million-ton/yr ethane cracker and six downstream chemical plants that will produce chemicals for plastics and other consumer products. The downstream chemical-production facilities include two large polymers plants (low-density and linear low-density polyethylene); an ethylene oxide/ethylene glycol plant; and three smaller, higher-value derivative plants that produce specialty alcohols, ethoxylates and alumina products. For any project of this magnitude, efficient wastewater treatment is essential in supporting effective plant operation.

Initial technology evaluation

Prior to building the Lake Charles complex, Sasol launched a technology evaluation program that spanned five years. The purpose of the program was to investigate a range of options for treating gas-to-liquid (GTL) wastewaters. After identifying membrane bioreactor (MBR) technology (Figure 1) as the most effective solution, Sasol invested heavily in MBR piloting, modeling and technology validation, which led the company to select a specific ultrafiltration (UF) hollow-fiber membrane (Figure 2) as the MBR technology of choice for addressing GTL wastewater treatment needs.

FIGURE 1. Membrane bioreactor (MBR) technology integrates membrane solids separation with a suspended-growth biological process in a bioreactor

FIGURE 2. The MBR used in this project featured special hollow-fiber ultrafiltration (UF) membrane cassettes

Treatment train design

Drawing from a broad portfolio of technologies to use in conjunction with MBR, a fully integrated multi-train wastewater treatment system was selected (Figure 3), with the objective to achieve a consistently treated effluent that would meet all local, state and federal regulations in terms of discharge quality. Following an initial equalization stage, to equalize the incoming waste streams, a dissolved-nitrogen flotation (DNF) unit was selected as a pre-treatment solution for oil and solids separation.

It is critical to guard against free oil in the incoming wastewater, and generally, free oil

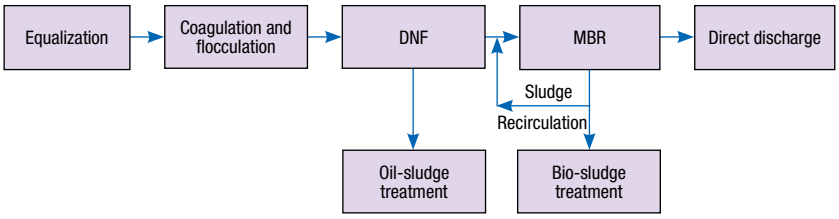

FIGURE 3. This illustration shows the overall wastewater-treatment scheme used for the Lake Charles chemicals complex

concentrations should not exceed 5 mg/L. For this reason, special attention should be given to the pretreatment selection. This reasoning was the basis for choosing DNF technology — a highly efficient pretreatment step commonly used in the hydrocarbon and chemical process industries (CPI) to remove suspended solids, grease and insoluble oil from wastewater prior to a biological treatment process. Composed of flotation units that use nitrogen gas, DNF treatment typically includes the following:

- Online coagulation for colloidal material
- A tank is provided for solids settling (floc formation) and oil coalescence to help form pin floc compatible with the flotation process
- A flotation tank equipped with a centrally driven surface-scraper mechanism
- A pressurization system for nitrogen dissolution under pressure and formation of micro-bubbles required by the flotation process
- DNF sludge tanks for sludge storage

Following the DNF, the MBR was the adopted solution for addressing the type of wastewaters produced at the Lake Charles Complex. This solution was especially well-suited for meeting Sasol's needs due to its capacity for robust removal of chemical oxygen demand (COD) and biological oxygen demand (BOD). At the core of the MBR system is the UF hollow-fiber membrane, which offers an absolute barrier to suspended solids, producing consistent high-quality effluent.

MBR technology integrates membrane solids separation with a suspended-growth biological process in a bioreactor. The membranes are immersed directly in the mixed-liquor suspended solids with permeate drawn into the fibers by a gentle suction mechanism. Contaminants in the wastewater are rejected by the membrane and retained in the process tank, providing solids-free treated water. The solids matrix on the membrane surface is non-pore-fouling and easily rejected. Additionally, the system can operate at low pressures with resulting low power

TABLE 1. DNF DESIGN PARAMETERS	
Parameter	**Value**
Coagulation retention time	4 min
Flocculation retention time	10 min
Flotation rise velocity (excluding recycle flow)	4 m/h at maximum flow
Recirculation rate (feed flow)	30%
Maximum water temperature	40ºC
Coagulant dosing	5 ppm as Fe^{3+}
Polymer dosing	1 ppm
Floated sludge concentration	35 gal/DS

costs compared to pressure-filtration processes.

Several design parameters must be considered to ensure a reliable MBR system. These are described in the following sections.

The organic loading rate, or F/M ratio. This is measured by the amount of food provided divided by the amount of biomass or reactor volume for a unit of time, and is a function of COD and the amount of volatile suspended solids (VSS). The value should typically range from 0.1 to 0.3 kg of COD per kg of VSS.

MBR hydraulic retention time (HRT). This is defined as the sum of all reactor volumes divided by influent flow. MBRs operate effectively at a shorter time compared to conventional aerobic systems. The typical HRT should range from 3 to 6 hours (2 to 4 hours in the aeration tanks, plus 1 to 2 hours in the membrane tank), compared to approximately 4 to 8 hours with conventional activated-sludge systems.

Solids retention time (SRT). This is the average time that the activated-sludge solids are in the system. The SRT should vary from 12 to 20 days, with consideration paid to the lower end due to the higher possibility of membrane fouling associated with lower SRT values. The average mixed-liquor suspended-solids (MLSS) concentration should typically be between 8,000 and 10,000 mg/L.

Oxygen uptake rate (OUR). This measures the oxygen consumption rate per mixed liquor volume. It should range from about 80 to 100 mg/L/h.

Water-treatment plant design

When completed, the full-scale 1,200-gal/min wastewater-treatment plant was engineered to handle a complex wastewater flow resulting from multiple combined waste streams generated at the Sasol Lake Charles complex.

TABLE 2. EFFLUENT QUALITY AND CHARACTERISTICS FOLLOWING DNF TREATMENT	
Parameter	**Design value average**
Wastewater flow	352 gal/min
Wastewater temperature	35.6°C
Total suspended solids (TSS)	25 mg/L
Volatile suspended solids	22.5 mg/L
Chemical oxygen demand	1,275 mg/L
pH	7.0
Alkalinity	250 mg/L as $CaCO_3$

To equalize and homogenize the varying concentrations of different wastewaters originating from the different chemical plants, an equalization tank is used at the beginning of the overall treatment process. After the equalization stage, two identical DNF treatment units (DNF Train A and DNF Train B) were designed to add redundancy to the wastewater treatment system and mitigate risks associated with equipment failure. Each unit is designed for an average flow of 600 gal/min, a maximum flow of 750 gal/min, and incorporates its own in-line coagulation, flocculation tank, flotation tank and pressurization system. Both pressurization systems include a pressurization vessel and two DNF recycle pumps (one duty and one spare) that recycle recovered sludge from each DNF unit to a respective sludge tank for storage.

TABLE 3. BIOLOGICAL SYSTEM DESIGN

Biological trains	2
Aerobic tank volume per bio train	196,500 gal
Total aerobic volume (excluding membranes)	393,000 gal
Membrane tank aerobic volume	38,800 gal
MLSS design	8,000 mg/L
Minimum water depth	18 ft

Circular DNF units were adopted for the project to achieve better distribution through one single-inlet distribution chamber, which ensures even distribution of the floating material across the entire surface area. Use of a single mixing chamber allows gas bubbles to attach to the incoming flocs.

The DNF sludge tanks were equipped with a vertical mixer to ensure adequate sludge homogenization. From the sludge tank, the sludge is pumped to a three-phase vertical centrifuge, which separates water, oil and solids. The DNF design parameters are summarized in Table 1.

Following DNF treatment, the effluent is then conveyed onward to the MBR package for aerobic biological treatment of an average flow of 352 gal/min in a 2 x 100% configuration and a COD of 1,275 mg/L, as shown in Table 2.

Like the DNF units, the MBR package also incorporates two treatment train lines. At the beginning of each treatment train, effluent from the DNF units enters a large concrete basin where air bubbles are introduced into the water from diffusers mounted on the bottom of the basin. The water flows via gravity to the membrane tank, which houses the membrane cassettes. A portion of the wastewater is sent back to the bioreactor by return activated sludge (RAS).

The biological system consists of two trains, each designed for a capacity of 196,500 gal and MLSS concentration of 8,000 mg/L, as shown in Table 3. The bioreactor is designed with a sludge retention time (SRT) of 31 days, an oxygen uptake rate (OUR) of 44 mg/L/h, and a

TABLE 4. ULTRAFILTRATION SYSTEM DESIGN	
Number of membrane trains	2
Number of cassettes per train	4
Number of cassette spaces per train	4
Number of modules per train	168
Total number of installed cassettes	8
Total number of installed modules	336
Spare space	12.5%
MLSS design	10,000 mg/L
Dimensions per each membrane tank (W x L x H)	10 ft x 28.8 ft x 12 ft
Average operating volume per each membrane tank	19,400 gal
Total membrane tank operating volume	38,800 gal

TABLE 5. EFFLUENT QUALITY		
Parameter	**Values**	
	Daily Average	Daily Peak
Biochemical oxygen demand ($cBOD_5$) (mg/L)	≤ 27	≤ 75
Chemical oxygen demand (mg/L)	≤ 190	≤ 520

food-to-mass ratio (F/M) of 0.2.

The two UF membrane trains contain four cassettes per train, which are installed in 316 L stainless-steel membrane tanks. Membrane filtration is designed to treat average and peak flows, including when one train is off-line (N-1 condition). The MLSS concentration within the membrane tank is 10,000 mg/L, as indicated in Table 4.

The MBR permeate quality parameters for COD and BOD, expressed in daily average and peak flows, are shown in Table 5.

The waste activated sludge (WAS) from the MBR package is sent to a bio-sludge treatment unit for settling and dewatering. Further settling is achieved by a thickener, wherein polymer is added to create large settled solids. This sludge is scraped off the bottom of the tank and pumped to a holding tank where an aeration grid prevents the solids from settling and becoming septic. From there, sludge is pumped to a continuous belt press for dewatering and hauled offsite for disposal.

Plant startup and commissioning

Once startup and commissioning of the wastewater treatment plant commenced in October 2018, stable operation was achieved around two months into the project. The initial "mechanical checkout" and hydraulic guarantees of the systems and equipment were performed for each unit. Internal inspections of the DNF units included the following steps:

- Checking the vessels and the pressurization tanks
- Verifying that the sprayer headers and nozzles were correctly installed
- Examining the bottom-sludge and floating-sludge scrapers, as well as the weirs for each train

After the coagulation and flocculation mixers were inspected, water was fed from the equalization tanks through DNF Train A to test the nitrogen pressurization tank and controls. The system is now running at 80 psi with a 150-gal/min recycle rate (25% recycle at a 600-gal/min flow design).

Jar tests were performed to test and optimize the chemicals needed for coagulation and flocculation in the de-oiling process. Subsequently, Train A went into service and the effluent tank control was changed to level control based on the flow coming from each DNF train, as well as the combined flowmeter from the DNF effluent pumps.

During the acclimation period, the MBR system was operated without permeation and the MBR aeration blowers were operated continuously in manual mode. The return activated-sludge (RAS) pumps were run continuously in manual mode while dosing with urea and phosphoric acid, as necessary. The COD loading was maintained using ethanol. Samples were taken daily to monitor COD loading, urea and phosphoric demand, as well as MLSS and mixed-liquor volatile suspended solids (MLVSS) concentrations. Once the minimum MLSS levels were reached, wasting was initi-

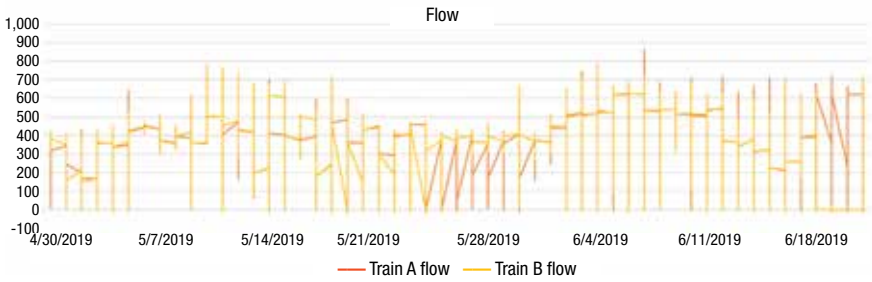

FIGURE 4. The MBR permeate flows (gal/min) for Train A (orange) and Train B (yellow) are shown

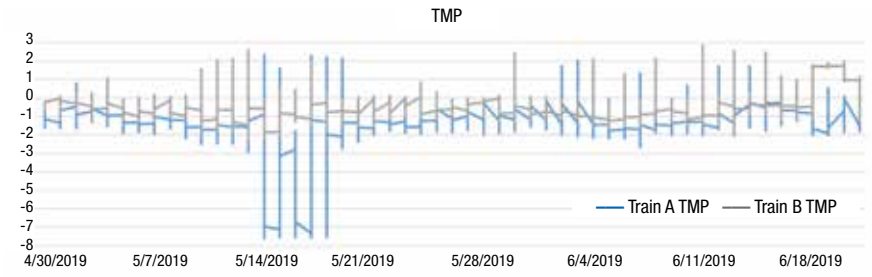

FIGURE 5. The trans-membrane pressure (TMP, in psi) for MBR Train A (blue) and Train B (gray) were relatively stable

ated via the WAS pump to maintain the desired sludge age. Once stability had been achieved, Train A was placed into automatic mode at 10-min cycles with back pulse. Once the waste COD loading was sufficient, the ethanol feed system was deactivated.

Operational data

Once the influent wastewater was relatively stable, the treatment plant began operating on a continuous basis, with an average flow of 398 gal/min for Train A and 365 gal/min for Train B for the first 45 days of operation. These results are shown in Figure 4.

The trans-membrane pressure for Train A had an average of –1.35 psi with some peaks in the week of May 14, 2019 due to higher MLSS, as shown in Figure 5.

Ammonia discharge levels in the first 45 days of operation showed a permeate discharge average of 0.41 parts per million (ppm). After a slight peak of 2 ppm on May 6, the discharge levels quickly returned to average values, as shown in Figure 6.

Average COD levels in the MBR permeate were slightly above 30 ppm and stable during the first 45 days of operation, except for June 18 when COD levels spiked to almost 200 ppm correlating with the startup of the ethylene oxide-ethylene glycol plant. When the startup occurred, 300,000 gal of ethylene glycol waste from the purification beds with 120,000 ppm of COD surged into the bioreactor, overwhelming the bacteria and significantly decreasing biodegradation. But once normalized, COD returned to normal values.

Wastewater COD values entering the DNF units have an average of 1,275 ppm. At the end of the entire treatment train process, MBR permeate had a COD average of 190 ppm, representing more than 86% removal.

These data demonstrate that, at the core of the Lake Charles Complex wastewater treatment solution, MBR technology utilizing UF hollow-fiber membranes provides high levels of COD and BOD removal, combining secondary and tertiary treatment in a compact footprint. In addition to the design parameters listed previously, facility owners evaluating MBR for wastewater treatment should bear in mind the following considerations:

- MBR systems are designed at lower F/M ratios than conventional activated-sludge systems to avoid high membrane fouling rates and low oxygen transfer efficiencies [*1*]
- MBR technology should be considered where stringent effluent discharge levels are required, with regards to BOD and TSS, as well as total nitrogen (TN) and total phosphorus (TP)
- UF membrane separation performance is independent of the quality or condition of the biological process fluid, and the entire treatment process is simplified
- MBR is an adequate biological wastewater treatment technology for GTL plants, as proven with pilot testing and proof of concept at Sasol
- At Sasol, COD removal of 86% with an average below 30 ppm has been achieved during the first months of operation ■

Edited by Mary Page Bailey

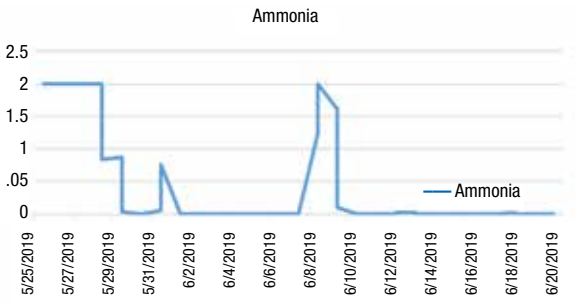

FIGURE 6. The MBR ammonia permeate readings, in ppm, are shown here. Note that a reading of 0 ppm corresponds to a value < 0.015 and a reading of 2 ppm corresponds to values > 2.0

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Making it clear – the water quality standards of NSF/ANSI 61 and 372

A-T Controls' NS Series floating ball and butterfly valves are certified to meet the requirements of NSF/ANSI 61 & 372. This means that NS Series valves are certified for use (UL) in water treatment, water purification, potable water, and water distribution systems, conforming with North American lead content requirements for "lead-free" plumbing.

To make the products safe for water distribution there must be protective barrier material, joining, and sealing materials. These materials will ensure that the water remains free from any contaminates that may be present on or in the metal, paint, gaskets, lubricants, etc.

A-T's NS butterfly valves are available in sizes 2" – 24" and have Class 150 flanges. NS Series ball valves are available with threaded, socket weld, butt weld, Class 150, and Class 300 end connections. Count on A-T Controls for material selection for your water application.

www.atcontrols.com

Series NS Resilient Seated Butterfly

Series NS20 Floating Ball Valve

Desert WWT plant shows off toughness of AUMA actuators

AUMA electric actuators have a proven track record spanning more than 50 years in industrial and municipal waste water treatment (WWT). Their robustness, corrosion resistance, powerful remote diagnostics and flexible communications protocols, including Industrial Ethernet, are key factors in purchasing decisions.

A case in point is the huge Jebel Ali sewage treatment project in Dubai. 200 AUMA actuators have provided reliable valve operation at the plant's Phase 1 site since 2008. Now, 200 new AUMA actuators have been installed at the Phase 2 site, which adds 375,000 m^3/day of treatment capacity, equivalent to a population of 1.35 million.

The AUMA actuators automate a wide variety of gate valves, butterfly valves and penstocks at all stages of the treatment process. IP68 enclosures (dust-tight and waterproof to 8 m immersion depth for 96 hours) and unique anti-corrosion coatings protect the actuators against desert sand and salt.

AUMA's scope of supply includes 200 SA multi-turn actuators with intelligent AC actuator controls, some also combined with AUMA gearboxes. The largest units are six GS 400 part-turn gearboxes that control flow in a DN1800 pipeline, delivering a maximum torque of 125,000 Nm. All actuators are centrally controlled using Profibus DP.

www.auma.com

More than 400 AUMA actuators provide reliable valve automation at Jebel Ali sewage treatment plant in Dubai.

We Are in the Solutions Business

Across a broad range of industries and applications, FTC optimizes filtration and separation efficiency.

A recently-delivered skid unit provided by FTC for a U.S. West Coast customer (2020).

Whatever fluid process you are running, **FTC** has a filtration or separation solution that will save you time and money. Our inventory of filter media and element construction materials, combined with our testing capabilities, allows us to offer filter cartridge solutions with proper chemical and thermal compatibility to withstand the most challenging environments. FTC's vessels are designed and constructed to meet every industrial performance and safety standard, and to work with our superior filters to optimize process efficiency. Most of all, our turnkey filtration solutions provide measurable, reliable performance throughout an extended service life unlike anything you have seen before.

Like others, we can provide standard equipment and filter options that have been in use for decades. Unlike anyone else, however, we take the time to listen to your needs and work with you to evaluate your fluid process goals, deliver optimized results, and even engineer custom filtration and separation solutions tailored to your specific requirements.

FTC is a different kind of filtration and separation provider. We support a wide range of markets within industrial fluid processing, and we work closely with our customers to understand the diverse contamination control challenges they face. Our products and systems filter many fluids with unique chemistries, temperatures, viscosities, densities, concentrations of solids, particle size distributions, and particle properties. Our customers want solutions to their specific problems, to challenges that are unique to industries including water treatment, oil & gas, food & beverage, chemical production, and power generation. At FTC, we have the experience and expertise necessary to deliver the solution they need.

No matter what business they are in, our customers all share a steady focus on process reliability and improved process efficiencies. They expect more reliable filtration performance, higher flow capacity, lower clean pressure drop, longer online filter life, smaller footprint, lower energy demand, minimal operator exposure to hazardous fluids, and the reduction of waste.

When operations budgets are stretched to their limits, the same old standard approach will not deliver the results you need. For new thinking about ways to save on CAPEX and OPEX budgets, FTC is your partner in optimization.

Remember this: where others see limitations, we see opportunities. Talk to an FTC representative today and learn about some of the ways we can redefine success for your process.

www.ftc-houston.com

900 Series industrial monitor/controller

Water quality testing requirements are diverse and complex. Regardless of the application the quality of the water is a make-or-break, critical characteristic that determines success or failure. The kind of instrumentation needed to meet the needs of this exacting array of uses must be reliable, accurate, simple to use, and also must be very flexible.

The 900 Series' suite of signal inputs can be configured to display a variety of measurement types: Conductivity, Resistivity, Salinity, TDS, pH, ORP, Temperature, mVDC, Flow, Pulse and % Rejection are all available. The 900 Series also includes a 4 to 20 mA current loop, two-wire transmitter input that can be defined and scaled to display measurements how you need them displayed. The instrument's display can show from 1 to 4 of these inputs simultaneously, or constantly cycle though a series of single measurements.

The 900 Series' outputs also provide flexibility. Standard outputs include a 0-10 VDC recorder output and a single alarmable relay output. Optional output card adds a 4-20 mA current loop output, an RS-485 digital data output and two additional alarmable relays. Alarm status is clearly displayed with attention getting alerts.

This is the ideal monitor/controller for the widest range of water related applications: agriculture, municipal water treatment, reverse osmosis, pharmaceuticals manufacturing, food and beverage production, desalinization, waste water management, pool and spa treatment, paper and pulp manufacturing; to name just a few.

The **Myron L®** Company 900: A high level performer for applications where high level performance is an absolute requirement.

www.myronl.com

Plastic Control Valves Handle Corrosive Chemicals

Collins 2-in. valves and actuators are specially designed to handle corrosive fluids – acids, bleaches, chlorine, pH control – and aggressive environments

Collins Instrument Company's line of economical 2-in. flanged plastic control valves handle corrosive liquids including hydrochloric acid, caustic, sulfuric acid, and many others. With bodies of either PVDF or polypropylene, these highly-responsive control valves are specifically designed for use with corrosive media and/or corrosive atmospheres.

Suitable for applications in numerous industries, including chemical, petrochemical, pulp and paper, and municipal, these valves are extremely corrosion-resistant, and feature fast-acting positioning (stroke rate approximately ½ in./s). They are available with a wide selection of trim sizes, in globe, angle, and corner configurations.

The differential-area piston eliminates the necessity for auxiliary loading regulators. All actuator parts apart from the integral positioner are molded of glass-filled, UV-inhibited polypropylene. Before shipment, the aluminum positioner and a portion of the cylinder are immersed in Dip Seal to provide atmospheric protection.

Plastic valves and actuators from Collins

The integral positioner eliminates the need for external linkages which are subject to corrosion and malfunctioning. Valves may also be furnished without a positioner for on/off applications.

Collins also offers a plastic pneumatic actuator. The combination of a plastic actuator and a plastic valve body provides an effective way to handle both corrosive materials flowing through the valve, and harsh environments that can attack the outside of the valve and actuator. Collins plastic control valve packages withstand salty marine atmospheres as well as industrial environments that are too corrosive for metal valves and actuators.

Collins actuators incorporate a unique internal locking ring to attach the cylinder to the yoke. A semicircular groove is machined inside the lower edge of the cylinder, and a matching groove cut in the yoke. When the yoke and cylinder are assembled, a flexible polypropylene rod is inserted into the groove through a slot in the side of the cylinder, securing the two sections together.

Along with its corrosion resistance the Collins control valve features a stem packing arrangement that virtually eliminates the problem of fugitive emissions, thereby protecting the environment.

Located on the Texas Gulf Coast in the town of Angleton, Collins Instrument Company has been serving the chemical and petrochemical industry for over 65 years. **www.collinsinst.com**

Smooth, Quiet & Efficient Chemical Feed

The Peristaltic Solution to Chemical Dosing

Flex-Pro Peristaltic Metering Pumps are currently offered in three model sizes. All of which are designed to deliver smooth quiet pumping action and precise chemical feed.

Flex-Pro peristaltic units offer an exclusive heavy-duty pump head tubing in multiple sizes and material options, designed to meet a wide range of chemical compatibility requirements. The Multi-Tube design delivers tube life up to four times longer than average single tubes. Because of the extended tube life, pump maintenance and related costs are greatly reduced.

Flex-Pro pumps are engineered to be rugged and efficient with two CNC machined rollers and two alignment rollers for optimum squeeze and tube life. The single-piece heavy duty rotor means no flexing and increased accuracy, with no metal springs or hinges to corrode.

The sturdy pump head cover is a clear acrylic that has been annealed for added strength and chemical resistance. There are no tools required for pump head cover removal during routine maintenance allowing for quick and easy access.

Flex-Pro peristaltic pumps help provide solutions in a number of industries. Two examples are:

A popular craft brewing company located in California has been using A2 Peristaltic Pumps to assist with the purification of wastewater generated by its brewing process. The brewery and the packaging hall generate about 100,000 gallons of wastewater per day. They use two Flex-Pro A2 pumps, one injects a solution of 12.5% sodium hypochlorite into the membrane bioreactor filter backwashes, and 93% sulfuric acid prior to reverse osmosis, the second pump injects 12-14% sodium hydroxide to bring reclaimed water to a pH of 8 to prevent pipe corrosion.

An energy company located in Florida uses Flex-Pro to inject 12.5% sodium hypochlorite into reuse water to prevent biological build up within the water tubes of their condenser. Any build up within the condenser would greatly reduce efficiency to produce steam, hence less mechanical power.

Flex-Pro Peristaltic Metering Pumps are manufactured in the U.S.A., and are NSF, ETL, CE listed. NEMA 4X / IP66 rated. **Blue-White** is ISO 9001:2015 Certified. Output rates range from 17.2 GPH (65.1 LPH) up to 158 GPH (600 LPH) at max pressure of 125 PSI (8.6 Bar).

www.blue-white.com

When Dealing With Corrosive Water Enviroments, Consider Kynar® PVDF Piping Systems

Kynar® PVDF piping can offer upgraded performance over high-end metallic systems

Plastic drainage systems for laboratory and chemical waste containment are commonly installed to safely convey a variety of fluids. From diluted chemicals to aggressive by-products and heat caused from mixing chemicals, it is important that containment systems can withstand any challenge. For highly aggressive fluids, or high temperature challenges, **Kynar®** fluoropolymer piping offers nearly universal chemical resistance for low-pressure service and is rated at 150C per UL® RTI testing.

Kynar® 740-02 piping installed in plenum to transport acidic waste.

Kynar® PVDF, like other polymers, is lightweight and easy to join using mechanical fittings, heat welding or electrofusion. Complete waste drain systems are available up to 10" diameter (larger diameters can be fabricated) and are UL® listed and labeled meeting the stringent requirements of ASTM E84 (25/50) without modifications to the test standard, and NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems, for use in plenums and concealed spaces.

Combination of Kynar® 1000HD and Kynar® 740-02 piping in underground concealed space.

The availability of chemical waste drain systems is complimented in industrial applications by the availability of Kynar® PVDF lined steel, FRP dual laminate Kynar® PVDF lined pipe, Kynar® PVDF Schedule 80 & SDR solid pressure pipe systems, and Kynar® PVDF biotech flexible tubing systems mechanically connected to injection molded Kynar® PVDF fittings. Based on lifetime performance, these systems, when used to handle hot strong acids, bleach, alcohols, ozone, peroxides, bromine, and changing chemical mixtures, are cost effective vs. exotic metals, fluoropolymers, and other engineering polymers.

www.kynar.com

Dräger puts customers in control of their safety.

No matter the industry, **Dräger** is a proven leader in safety equipment – from fixed fire and gas detection systems to portable gas detection and respiratory protection. Dräger protects, supports, and saves lives around the world in hospitals, water and wastewater applications, industrial manufacturing, fire departments, government, mining and more.

Whether dealing with toxic or explosive gases, from Hydrogen Sulfide to Hydrogen, Dräger specializes in offering tailored solutions to their customers' specific applications. Each of the fail-safe Regard 7000 controllers can monitor up to 1536 inputs, and works seamlessly with one of the most comprehensive gas and fire detection sensor lines in the industry.

Dräger is a leader in the industry in innovation to not only reliably and accurately monitor gases and flame, but also to offer a complete solution including hazard analysis with gas mapping, gas sampling systems, and advanced controllers using the latest communication protocols. The Regard 7000 controller can automatically initiate ventilation, equipment shut-down and send out emergency notifications.

In addition to the Regard 7000 controller, Dräger's proven DrägerSensor technology is well-known for its accuracy and ability to withstand even the harshest conditions:

- Electrochemical: a larger electrolytic reservoir and unique formulation result in industry-leading sensor lifetimes (up to 5 years or more) and sensor temperature ranges: from -40° F to 65° F. Over 150 target gases can be monitored, such as H_2S, O_2, NH_3 and Cl.
- Catalytic Bead: the newly launched, proprietary DQ sensor design with two uniform active pellistors has increased signal stability (especially for hydrogen, ventilation systems and aspirated systems with pumps) and faster response times.
- Infra-Red (absorption for gases): the Dräger Polytron 8700 uses a unique 4 beam IR detector for increased reliability, especially in humid and dusty environments, and also nearly eliminates drift.
- Infra-Red (radiation for flames): the Dräger Flame 2700 uses a multi-spectrum infrared (MIR) technology to detect hydrogen flames at up to 98 ft (30m) in less than 5 seconds.

- Open path: the Pulsar 7000 is Dräger's top-of-the-line open path LEL detector, with one of the simplest and fastest alignment procedures in the industry, combined with an innovative solution to avoid false alarms – a self-test feature and a beam blockage indicator. Plus, it has an industry-leading 0 to 8 LEL m maximum measuring range and up to 656 ft (200m) coverage area.

Dräger has been a leader in gas detection for over 130 years, and is continuously innovating to provide award-winning safety solutions for their customers. Dräger can be counted on as a trusted advisor with innovative safety solutions. Learn more by calling 1-800-4DRAGER or by visiting

www.draeger.com

Smart actuator optimizes control valve performance

The new Smart Electric Valve Actuator (SEVA) from Badger Meter stands up to extreme conditions while providing exceptional position accuracy

Since 1905, **Badger Meter** has been recognized as a leader in the development and manufacture of flow management solutions. The company has introduced the latest generation of its Smart Electric Valve Actuator (SEVA) solution, which now offers Modbus RTU, Modbus TCP/IP and SoloCUE® connectivity.

SoloCUE connectivity

SoloCUE is a software solution that provides easy access to the setup of both the feature-rich SEVA and its protocols. This custom-built, bulletproof platform allows end-users to visualize SEVA's performance and setup characteristics.

Product design

SEVA employs cutting-edge technology and delivers exceptional accuracy and repeatability. Designed for extreme conditions, the actuator has military-grade components.

SEVA has 100-lb. and 200-lb. thrust models. There are several options available for communication protocols, including Modbus RTU, Modbus TCP/IP and the Industrial Ethernet Protocol (EtherNet/IP). It is is certified by FM, EX, CSA and CE. The actuator allows for both linear and Device Level Ring (DLR) ring network topologies.

Position accuracy

SEVA provides an exceptional level of position accuracy (±1% of full scale) with five available positions when there is a loss of power. The device also features four positions when there is a loss of signal. Both the full closed and full open positions are defined during setup.

In addition, SEVA has an internally powered (active) feedback signal, which actively communicates stroke position to the control system. Its feedback sensors are crucial in more precise applications. SEVA even provides a manual override capability to help the operator in loss-of-power situations.

Other features

The SEVA assembly has the option to include two user-adjustable limit switch outputs. An external signal is provided once the set points of the limit switches are met. Furthermore, the electric actuator can split the incoming 4–20 mA signal and use either the lower or higher range of the signal for full stroke operation. A hyper terminal server makes it possible to change the type of split range.

SEVA was specifically designed to minimize the number of models needed to work with different electrical demands. Its Universal AC Input with voltage protection will work with 115 V AC, 230 V AC and 24 V DC power supplies. This feature ensures confidence that the actuator will provide a single source for different process needs. SEVA can receive analog input signals from 4–20 mA, 0–5 V DC or 0–10 V DC.

badgermeter.com/chemicalSEVA

Static mixers with low pressure drop

Ross LPD Low Pressure Drop Static Mixers are ideal for effective fluid mixing in water and wastewater treatment processes

The **Ross** Low Pressure Drop (LPD) Static Mixer enables more efficient dosing of flocculants, disinfectants, neutralizing agents and pH conditioners into a water stream. This simple-to-install heavy-duty device completely mixes treatment chemicals within a short length of pipe. When used in conjunction with automated instrumentation, the LPD delivers predictable quality control based on a virtually maintenance-free operation.

Four or six mixing elements are usually more than sufficient for effective mixing under turbulent flow conditions, Ross says. Diameters range from 1 in. through 48 in.

The LPD Static Mixer consists of a series of baffles or "elements" discriminately positioned in series. Each element comprises a pair of semi-elliptical plates set 90 degrees to each other. The next element is rotated 90 degrees about the central axis with respect to the previous baffle set, and so on. For even lower pressure drop, an LLPD model is also available, in which the plates of each element are oriented at 120 degrees relative to each other.

As the fluid moves through each LPD or LLPD element, flow is continuously split into layers and rotated in alternating clockwise and counterclockwise directions. This method of subdividing the stream and generating striations leads to highly efficient and repeatable mixing with minimal pressure loss. During turbulent flow, the baffles enhance the random motion of molecules and the formation of eddies. In most water and wastewater processes, four or six elements are more than sufficient to completely disperse treatment chemicals and create a very uniform solution or suspension.

Small LPD/LLPD mixers of 1 in. through 2.5 in. in diameter are welded to a central rod, while larger elements are welded to four outside support rods for maximum rigidity and stability. Available in a wide range of sizes up to 48 in. in diameter, these mixers can be supplied as pipe inserts or as complete modules with housing and injection ports.

In addition to Static Mixers, Ross also manufactures High Shear Mixers and Multi-Shaft Mixers used in the production of water treatment chemicals. The company offers no-charge mixer testing services and an extensive trial/rental program.

www.mixers.com

Process Changes: Understanding and Mitigating Fire- and Life-Safety Risk Factors

When making a change in your process, do not overlook new potential hazards that may arise, as discussed here

McKenna Pearson
Telgian Engineering & Consulting, LLC

Large-scale chemical processing can be inherently risky. This is especially important to keep in mind when making changes to a process. As we have seen recently during the COVID-19 pandemic, many companies have begun creating essential new products, from hand sanitizer to plastic face shields. If new raw materials are used, or if existing equipment is used to create a new product, the associated hazards may also change. During an emergency, once a new process is operating, it is easy to overlook any new risks that have been created. Many factors must be considered, and some may require council from a fire- and life-safety professional. Among the major considerations for confirming that fire and life safety systems are adequate for your process are: ensuring the proper storage of hazardous material, considering the risk of the process to the facility, and system maintenance.

Storing new hazardous materials

A major factor that should be examined in detail when making any changes to a chemical process is the storage of any new hazardous materials (Figure 1). These can be raw materials, finished products or waste. Just a few considerations include the specifics on how to store these materials, as well as the overhead fire sprinkler protection required for the specific hazard posed. Some of the top fire and life safety hazards are flammable and combustible liquids (such as ethanol, isopropyl alcohol, gasoline or any oil derivative), dust hazards (created from such operations as milling, agricultural and food processing), and Group A plastics.

FIGURE 1. A new process could entail the storing of new hazardous materials, such as flammable solvents, finished products or waste

While the risk posed by storage of any hazardous material should always be considered, this has become particularly imperative during the pandemic. When personal protective equipment (PPE) shortages hit the doctors, nurses and first responders, many people asked themselves: what can I do to help? The answer for some was to make masks at home with scraps of fabric and their sewing machines, while others went to work reconfiguring their equipment to produce plastic face shields, ventilators and even hand and surface sanitizers. This has caused many professional processes to operate outside of their original design parameters. Consequently, some facilities started storing and utilizing large quantities of flammable and combustible liquids and Group A plastics that were not storing these items before.

One example is the local wineries and breweries that began making and distributing hand and surface sanitizers. It is important to note, the average alcohol content of beer is approximately 5% and wine is approximately 12%, according to the National Institute on Alcohol Abuse and Alcoholism [*1*]. The alcohol content of the sanitizing products ranges from 60 to 80%. While the intent of this creative way to support the community is noble, fire protection systems in these facilities may not be capable of adequately protecting the increased hazard that comes from storing and processing large quantities of a highly flammable liquid (Figures 1 and 2). For instance, fire- and life-safety systems designed for distilleries must consider the quantity of spirit that will be maintained on-site in order to appropriately protect the facility and people within it. Breweries and wineries often do not require the same level of protection.

Additionally, companies from many industries have started producing medical equipment, such as plastic face shields, face masks and ventilators. Most notable are the companies in the automobile industry, but local manufacturers of electrical equipment and furniture have also answered the call. Medical products are subject to strict regulation that extends to how the products are manufactured (Figure 3). Not only can the onsite storage of hazardous materials (think Group A plastics used for

the plastic face shields) change, but the facility may also undergo structural changes to comply with the requirement to maintain a dust-free manufacturing environment.

One of the main hazards associated with converting production to plastic face shields, from either a less hazardous process or a process posing a different risk, is the storage of Group A plastics. This type of plastic is classified by having a higher heat of combustion and a higher burning rate than other plastics and includes materials such as polyethylene terephthalate (PET), natural rubber, polypropylene, acrylic and polyvinyl chloride (PVC). These plastics can be especially hazardous in a fire because they ignite quickly and easily but also burn incredibly hot. Protection for storage of this classification of plastics is generally much more stringent compared to storage requirements for other items.

A few key questions to answer while considering the storage of non-native materials in your facility are as follows:

- Where is the hazardous material being stored?
- What is the proper container for storage of this material?
- How much will be stored?
- If a large quantity will be stored, how will it be stored? Will racks or shelving be used? What else might be stored nearby or within the same racking?
- Do the building materials and construction of this facility support this type of storage?

Again, it is important to consider retaining the services of a fire- and life-safety professional when making changes to your facility.

Process risks to the facility

When a chemical process is being developed, it is expected that a hazard and operability study (HAZOP), hazard identification study (HAZID), or another method of "what-if" analysis will take place before and during the development. This type of study often starts small, by breaking the process down by each piece of equipment and imagining worst-case scenarios, in order to prevent or plan for them. The study then, effectively, "zooms out" further and further, until the entire process is viewed and analyzed. This exercise is very effective in preventing everything from everyday problems to cat-

FIGURE 2. Fire protection systems in facilities that have changed production to hand sanitizer, which has a high alcohol content, may not be capable of adequately protecting the increased hazard that comes from storing large quantities of flammable liquids

FIGURE 3. Medical products are subject to strict regulation that extends to how the products are manufactured

astrophic situations. Nonetheless, the analysis is often not viewed from a great enough distance to include the facility containing the process or the storage of the materials.

It is easy to mitigate risk and anticipate problems when a facility is being designed specifically for a process. This allows the fire sprinkler system to be designed with a specific risk in mind, the proper fire walls to be installed, necessary ventilation, and so on. It is not as easy to avoid these types of problems when changing a process in an existing infrastructure. The building materials, adjacent spaces, type of construction, even nearby structures can affect what type of fire protection is required for a specific hazard.

The manufacturing of medical equipment in unrelated production facilities has led to changes in infrastructure to comply with U.S. Food and Drug Administration (FDA) regulations. In order to create the required dust-free environment, changes would typically include installation of walls or partitions and ventilation systems. Changes of this nature, even if only temporary, can create obstructions to the sprinkler system or cause the sprinkler heads to be over spaced. In either case, the primary concern is the sprinkler heads being unable to develop the appropriate spray pattern to reach all affected commodities and structures. This is a common occurrence when a new process takes over an existing space. Meeting ventilation requirements or even creating a space that is ideal for your process by adding or removing walls can greatly impact the fire protection criteria.

Sometimes the solution may be as simple as a few minor upgrades to the fire protection system or rethinking a storage arrangement, whereas other times it may be necessary to install a completely new system. When working with hazardous materials, such as flammable and combustible liquids, plastics or even combustible dust, it is important to know your facility has been designed with the protection of your process in mind.

System maintenance

The final consideration when confirming that the fire- and life-safety systems are adequate for your process is system maintenance. Once the risk has been correctly categorized, the proper fire- and life-safety protections have been installed,

and the process is operational, it is easy to take the protection for granted, especially during a global emergency. Nevertheless, as is the case with most equipment, the fire-protection and life-safety systems require regular testing, inspections, and maintenance.

Fire safety inspections extend beyond the overhead sprinkler system to include fire alarms, smoke and heat detection, and inspection of fire doors and emergency exits. Most wet-sprinkler systems require annual inspections, with some components of the system requiring quarterly inspections. If your process is protected by a foam-water sprinkler system, monthly inspections may be required. While this may seem excessive, regular testing and inspections are necessary to ensure that the fire- and life-safety systems will perform as expected in the case of a fire-related emergency.

According to a National Fire Protection Association (NFPA) study published in 2018 of the fire incidents in industrial and manufacturing occupancies between 2011 and 2015, only 20% were structural fires [*2*]. However, structural fires lead to the most loss and damage — with 49% of deaths, 80% of injuries, and 67% of direct property damage being cause by a structural fire. Manufacturing and processing facilities were responsible for 65% of the fires, which caused six deaths, 176 injuries and $540 million in property damage. Regular inspection, testing and maintenance can address any issues that arise in a timely manner and ensure your system is functioning properly.

Final thoughts

Whenever a change to a process is being implemented, it is important to consider any risks that may be created outside of the process equipment. This is especially important when introducing hazardous materials, such as flammable and combustible liquids and Group A plastics. Whether the risk is created by the raw materials, waste, or final product, the storage of any such materials and their associated fire hazards must be taken into consideration in order to ensure the fire- and life-safety systems can protect against the increased risk created by the materials and their storage arrangement.

If it becomes necessary to change existing infrastructure to accommodate a new process or if a change in process results in the addition or removal of any walls or ventilation systems, the impact on the installed fire- and life-safety systems must be taken into account. Changes such as the ones previously mentioned can have a big impact on the general safety of your building. Additionally, it is imperative that regular required testing, inspection and maintenance of these systems continue. Failing to properly maintain the fire- and life-safety equipment can result in millions of dollars of property damage, injury, and in some cases, death, if an emergency were to occur.

While addressing risk within the process is imperative, equally significant is examining the building or facility housing the process and how the raw material, products and waste are being handled within the facility. Including or consulting with a professional who has experience working with the International codes and the national standards will increase not only the protection of your process, but more importantly, the safety of your people. ■

Edited by Gerald Ondrey

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Author

McKenna Pearson is a fire protection consultant for Telgian Engineering & Consulting, LLC (900 Circle 75 Parkway, Suite 680, Atlanta, GA 30339; Email: mpearson@telgian.com) with more than three years of professional experience in the industry. Pearson collaborates with both team members and public agencies to manage, develop, integrate and analyze project schedules and expedite objectives. She assists clients by helping them to focus on critical activities to accomplish ultimate project and production goals. Pearson is responsible for reviewing existing fire alarm, suppression and life-safety systems. Her role requires her to uphold a working knowledge of relevant fire protection, risk, building codes and construction technologies. She also builds and maintains relationships with clients and officials. In addition to ensuring operational functionality and code and standards compliance, she responds to proposals, meets with stakeholders, and ensures project deadlines are met. McKenna has earned a B.S.Ch.E. degree from Montana State University-Bozeman and has received her EIT license.

Liquid Layers: Measuring Overall Level and Interface Points

Accurate interface level measurement is crucial to optimizing separation processes. Today's guided wave radar technologies make it possible to measure thin liquid layers with greater accuracy than ever

Denny Nelson
Emerson

A bottle of salad dressing can illustrate a challenging level measurement application. Like the situation with oil and vinegar separation, engineers may be called to determine the individual volumes of multiple immiscible products in a single vessel. Measuring the interface level in tanks or vessels is a common and vital objective across many process industry applications where immiscible products, like salad dressing, form distinct layers. Examples include oil over water, or low-dielectric organic solvents over acid.

Some liquids do not mix due to different molecular polarity or differences in specific gravity. When stored together, they separate into defined layers due to gravity. Accurately measuring the interface level between such products can be challenging, and if inaccurate, can lead to cross contamination, which can prove extremely costly. Newer technologies provide solutions.

Measuring interfaces

Guided wave radar (GWR) is effective and widely applied for interface level measurement (Figure 1), but it requires the top product layer to be of a certain minimum thickness to be measurable. Advanced technology in the latest generation of GWR devices can cut that minimum thickness in half or even less, helping users increase the efficiency of their operations and reduce costs.

The need to measure interface level arises when it is necessary to know the volume of the upper product layer, which can be determined from its thickness and vessel diameter. This could include situations when a user wants to drain off only the top fluid and requires an indication of when to stop. Interface measurement is also essential for efficient separation processes, where it is critical to control the flow of both fluids out of the vessel into independent channels with minimal cross contamination.

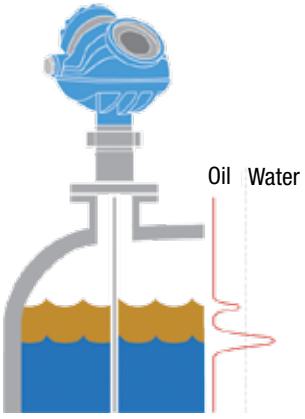

FIGURE 1. Guided-wave-radar level instruments are an effective solution for multi-product interface measurement in tanks

In most cases, the two liquids separate naturally because of their differing densities, with the lower-density liquid settling on top of the higher. For example, when oil and water occupy the same vessel, oil floats on top of water. The interface point to be measured in this example would be the upper level of the water and the lower level of the oil.

In an oil production process, a separator upset combined with a lack of visibility into the interface location can result in oil being sent to the water tank or water being sent to the oil tank, both of which are undesirable. Oil sent out with water gives away product and could result in environmental fines. Unrecovered oil in the water tank from a multiple well pad facility could siphon off more than $1 million a year of revenue, while excess water in the oil tank could cause an unexpected capacity loss, resulting in a spill or well shut-in from a high-level alarm.

The accuracy of interface measurement depends on the specific process conditions, such as the difference between dielectric constants of the products, and the presence of a distinct interface. Sometimes the fluids do not separate entirely, and instead form an emulsion or "rag layer" (a mix of the two products) between them. Typically, the thicker the emulsion layer, the more challenging it becomes to accurately measure the interface level.

Technology selection

The most basic way to measure an interface level is via a sight glass on the side of a tank. However, this method has some obvious disadvantages. First, it must be read manually, which is both time-consuming and labor-intensive, as it requires operator inspection. Second, a sight glass will not always give a clear indication unless there are multiple connections to the vessel to allow the interface in the glass to match what is in the vessel. Third, sight glasses need regular cleaning, and in applications where condensation can occur, this can prevent the operator making an accurate measurement.

Other level measuring alternatives capable of identifying an interface layer, at least to some extent, include floats and displacers, capacitance transmitters, ultrasonic transmitters, differential pressure meters and magnetostrictive sensors. However, these technologies have various limitations in terms of their resolution, accuracy, and reliability in challenging process conditions, plus maintenance requirements.

The many advantages provided by GWR in comparison has seen it be-

FIGURE 2. GWR level instruments are normally mounted on a tank roof through a flanged spud

come one of the most widely applied solutions in interface applications. GWR provides accurate and reliable measurements in vessels with tight geometry, in chambers, and in tanks of all sizes. No compensation is necessary for changes in the density, dielectric properties, or conductivity of the fluid. Moreover, changes in pressure, temperature, and most vapor-space conditions have no impact on its measurement accuracy. GWR instruments need minimal maintenance because they have no moving parts, and they can easily be installed as a replacement for older technologies, even while there is liquid in the tank.

In a GWR installation, the instrument's transmitter is usually top-mounted (Figure 2), with the probe extending to the full depth of the vessel. A low-energy pulse of microwaves, travelling at the speed of light, is guided down the probe. At the point of the liquid level, a significant proportion of the microwave energy is reflected up the probe to the transmitter when the pulse encounters the sudden change in dielectric constant when passing from air to liquid. The transmitter measures the time delay between the transmitted and received echo signal. An onboard microprocessor then calculates the distance to the liquid surface.

A portion of the pulse will continue down the probe through the top layer of liquid, and when it encounters the change in dielectric constant at the interface point, a second echo can be detected from the top of the second liquid at a point below the initial liquid level.

This works as described provided the liquid on top has a lower dielectric constant than the lower liquid, which is the case with oil on water since most oil products have a very low dielectric constant, <5 typically, and water is >50.

In the rare cases where the product lying on top has a higher dielectric than the one below, top-down measurement using GWR will be ineffective. In this circumstance the mounting position can be inverted so the instrument is installed on the tank bottom, but this will only be able to determine the interface position and not the top level.

Thin-layer measurement

The reason why the upper product must be of a certain minimum thickness when using GWR in interface applications is to enable the instrument to separate and distinguish the echoes of the two liquids (Figure 3).

For most GWR instruments available today, the minimum thickness must be between 6 and 8 in. (125

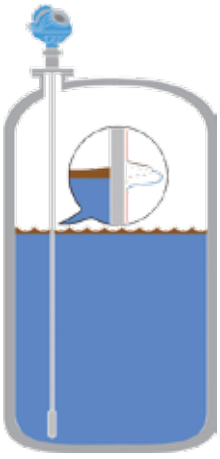

FIGURE 3. New software makes it possible for the instrument's transmitter to differentiate between two pulse echoes, even when they are very close together. This allows for accurate measurement of thin layers

and 200 mm) depending on the transmitter model and probe style being used. However, some instruments provide functionality that enables the minimum detectable thickness of the upper product layer to be cut in half, to 2.5 in. (60 mm). This improvement is possible because of new software algorithms that allow the transmitter to detect closely spaced signal peaks without having to decrease its signal bandwidth. Maintaining signal bandwidth allows the instrument to retain its high sensitivity and ability to handle disturbances. This helps operators improve insight into separation processes, therefore improving process optimization and reducing production losses.

The ability to detect a thinner upper-product layer is especially beneficial in cases where no second product should be present in the vessel. For example, detecting a hydrocarbon on top of methanol is an indication that there is something seriously wrong with the process. It can also be very beneficial in separators and scrapers, where the operation of a vessel can be optimized by reducing safety margins.

The tools available for oil producers and chemical manufacturers working with immiscible products are improving, allowing plants to optimize processes, resulting in increased operating efficiency and profitability. The ability to determine the contents of a tank, with thick or thin layers, can improve process control and possibly identify when something has gone wrong, allowing for timely corrective action. ■

Edited by Dorothy Lozowski

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Author

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Reliable and Cost-Effective Solids Feeding

A holistic approach to bulk-solids-feeding installations can improve the effectiveness and efficiency of operations involving solids handling

Richard Farnish
University of Greenwich

Many chemical processes involve the extraction of bulk solid materials at a controlled rate from a storage vessel for delivery into the process. The extraction of solid materials usually requires the use of technology that can deliver the solids into the process at the required feedrate and with minimal variation in rate when in operation. For every industrial installation, bulk solid material type and set of process requirements, a different optimal technology exists. This article presents some of the key considerations involved in obtaining reliable and cost-effective extraction from storage vessels.

One of the most important aspects of efficient feeder installation is to understand that adopting a holistic approach is required to optimize any type of feeder and solids-feeding process. Such an approach considers the storage vessel, the interface between the storage vessel and the feeder along with the feeder itself as a single project entity whereby each element of the process must be specified and designed to work together. For "clean sheet of paper" projects, this approach is usually more easily realized. However, in many cases, engineers are tasked with trying to make the most of retrofits and upgrades where budgets are rarely adequate to support such an ideal approach. In these real-world projects, the need to compromise is important in the delivery of effective solutions.

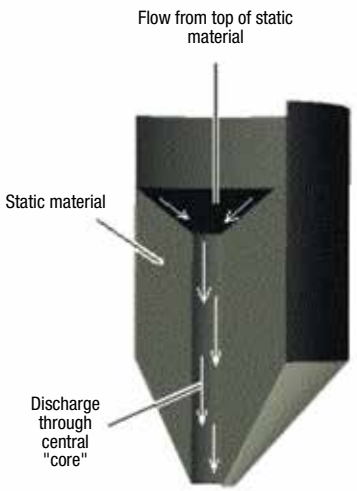

FIGURE 1. The illustration shows the concept of funnel/core-flow discharge

Consistent volume delivery

A fundamental requirement for most types of solids-feeding installations is that the delivery of solids into the process should proceed with consistent volumes or weights of the solids introduced into the process without any interruptions in feeding. These may sound like fairly undemanding requirements, but in too many solids-feeding cases, they remain elusive for many end users. Success in meeting these requirements is driven by the design of the feeder and the flow-channel profile that it develops, but is also driven by the inherent operational characteristics of the storage vessel.

Achieving any degree of consistency in the delivery of solids into a process requires a correctly designed and installed feeder and consistent bulk-material properties at the outlet (interface with the storage vessel). To do this, it is clearly important to consider the conditions of the bulk material that are prevalent at the outlet, and the influence of the storage vessel on those conditions.

Depending upon the vessel geometry, internal surface finishes and material characteristics, two basic flow patterns can develop in storage vessels: mass flow and funnel (core) flow. Simplified illustrations of these two operational behaviors appear in Figures 1 and 2.

Mass flow is characterized by the friction at the walls of the storage vessel (this is a function of the convergent angle of the vessel, the surface finish of the vessel walls and the interaction of these variables with a specific bulk solid) being sufficiently low to allow material to slide downward when the outlet cross-sectional area is fully active. Because the designed geometry is able to mobilize the friction at the wall, the flow of material toward the outlet approximates a cross-sectional plane drawn down. This flow pattern endows the vessel with the (very desirable) characteristic of operating on a "first-in, first-out" stock rotation — without any stagnant zones or risk of solids retention when the material drains down.

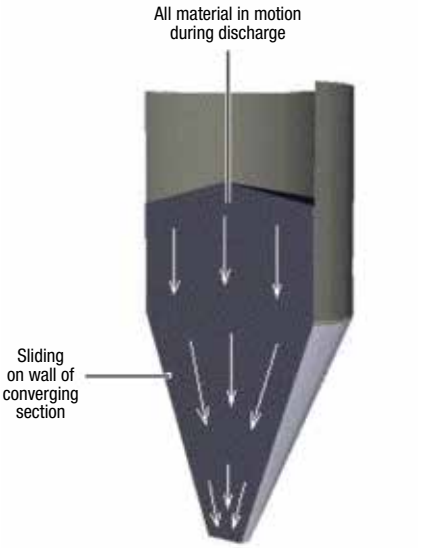

FIGURE 2. The diagram illustrates the concept of mass flow discharge

A very beneficial effect of establishing mass flow discharge is that the bulk density at the outlet is largely independent of the head of the material present above the outlet. Similarly, where segregation (by particle size, shape or density) occurs in radial or lateral forms, the cross-sectional drawn down serves to effectively recombine distributed

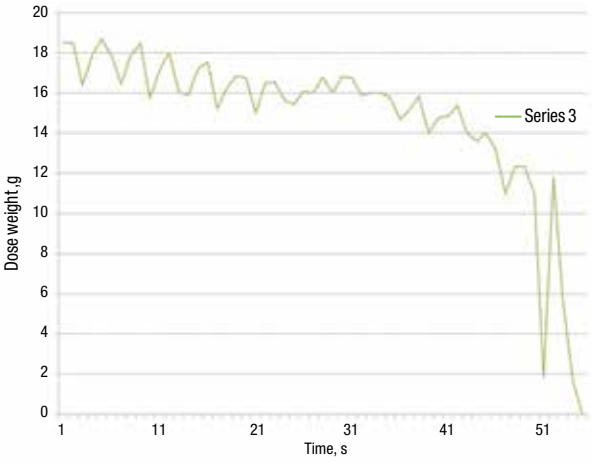

FIGURE 3. The graph shows the discharge characteristic for a standard screw feeder and agitator system operating in funnel flow

elements at the solids outlet. Thus, the most ideal conditions can be generated at the outlet to support feeder consistency and accuracy — these being minimal variation in bulk density and improved homogeneity (also associated with bulk density but often, more critically, associated with good blend composition).

Designing for mass flow

Attaining mass flow through the storage vessel is of critical importance where the accuracy of feeder operation is a main consideration. Reliability of discharge is a function of the outlet size required to prevent rat-holing or bridging (arching) of the solid material. This dimension can also be calculated for a given type of bulk solid, and should always be incorporated into the design and construction of mass-flow vessels.

Storage vessels that have been constructed without consideration of the bulk-solid properties will by default develop funnel (core) flow (Figure 1). Inappropriately high effective friction at the wall (caused by shallow vessel geometry or by high-friction surface finishes) means that when discharge occurs, material will be retained against the walls, and a preferential flow channel will propagate upward from the outlet. When such channels develop, material is drawn down from the top surface of the solids inventory. This type of flow behavior endows the vessel with a range of characteristics that, while not a major issue for some bulk solids, can cause serious issues for others (typically cohesive or time-dependent materials). These issues include retention, poor stock rotation, cross-contamination and exaggerated segregation effects. From the perspective of feeder performance, the greatest drawbacks are that the bulk density at the outlet is directly influenced by the head of material, and that segregation effects also influence not only bulk density, but also critically adversely impact blend quality.

Where many feeder installations fail is in the use of equipment that is incapable of drawing down from the cross-sectional area of the vessel outlet. As a default, most feeder types are what is termed fixed-volume devices (including standard screws, drag link, belts, rotary valves, and so on), which has the implication that if simply purchased and bolted onto the underneath of a vessel or bunker, a preferential draw will develop though the outlet of the vessel. The result of this is that any vessel (even one designed for mass flow) connected onto the equipment will default to funnel flow (which is the default for the majority of vessels anyhow).

One of the challenges for feeders employed in applications where good repeatability is a key objective, is that, if funnel flow is present (that is, for a fixed-volume-type feeder, suboptimal vessel geometry, or both), the bulk density developed in the feeder will be a reflection of the inventory level at any given moment (that is, the bulk density will oscillate as a reflection of emptying or filling cycles). Obviously, if the range of inventory variation can be controlled by feedback control based on load cells or level probes, then the variation in bulk density will be lessened. This approach is one of several reasons why it is not unusual to find subhoppers used for controlled feeding, where they are fed into from larger-capacity vessels. The less variation in bulk density that occurs, the simpler (and less expensive) the feedback control can be on the feeder.

Figure 3 shows the typical fall off in dose weight over the discharge to empty a small vessel where the geometry and feeder design factors have created funnel flow. The trend is very clear. By contrast, Figure 4 shows a modified version (to support mass flow) of the vessel in use with a modified screw. The stability of the bulk density in the feeder during the drain down to empty the vessel contrasts very strongly with the behavior of the funnel-flow system in Figure 3.

Many small-scale dosing systems employ agitators (usually as a default) in their design — the purpose of which is to prevent flow stoppage (since the dimensions of the dosing screws and their corresponding flow-channel volumes are invariably significantly below the rat-hole or arching dimension for the powder being handled). Such agitators may support flow reliability, but can also (in some designs) be responsible for cyclic variability in density

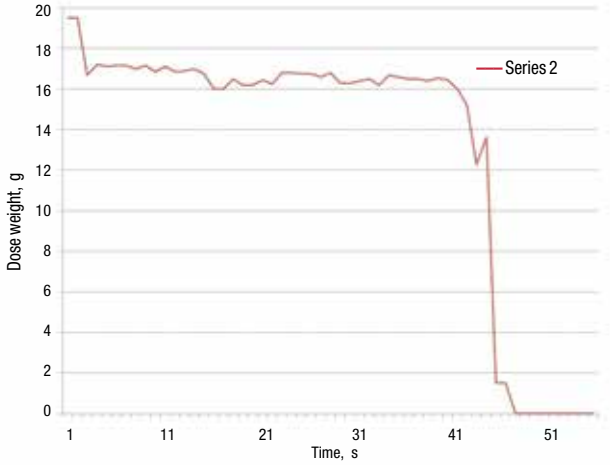

FIGURE 4. The graph shows the discharge characteristic for a modified screw feeder with the agitator system removed operating in mass flow

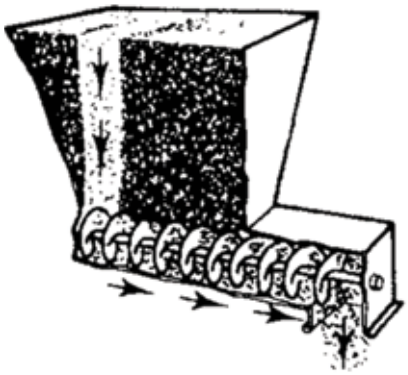

FIGURE 5. Preferential drawdown of solids material develops from the first pitch of a constant-capacity screw feeder

conditions. Again refer to Figure 3, where the peaks and troughs in the data are a direct function of the agitator blade proximity to the feed screw during rotation. A good-quality feedback-control loop for screw speed should be able to largely iron this out and, of course, it should be borne in mind that the magnitude of variation will be strongly influenced by many design and operational factors, including, of course, the bulk properties of the powder or granulate being dosed.

Pitch spacing and flow

Taking screw and auger feeders as a specific example of a constant-volume-type feeder, the defining feature for a standard unit in most cases will be that of constant pitch spacing and constant-diameter flights along its length. The unit would typically, but not necessarily, also feature a central shaft along its length to which the flights attach. Some types are shaftless and consequently have a helical appearance. These design features parallel those found in screw conveyors, which are used to transport material either horizontally or at an inclined angle over distances of up to 9–12 ft (before transfer to an additional unit is required).

Therein lies a very important difference in the function of the feeders and conveyors, namely that the former type operates with each

FIGURE 6. Evidence of a preferential flow channel can be seen in this agitated dosing system (the screw visible through a bed of compacted material)

"pocket" filled to capacity, while the latter would typically run at below 45% volume. Consider now the operating of a standard (constant-volume) screw feeder under a vessel. During each rotation, a void opens up at the back end of the screw, into which material can be drawn. The subsequent rotation creates another void at the back end of the screw and pushes the previously filled volume forward, but since all of the volumes along the screw are identical, it follows that no further capacity can be generated to draw

FIGURE 7. This diagram shows one of several design approaches to generate increasing capacity along a constant diameter screw

material down (other than that at the very first pitch). Thus, irrespective of the area of the vessel outlet, the only flow channel that will be generated will be defined by the dimensions of the first pitch spacing and the diameter of the screw. The consequence is that funnel flow will be established. Figure 5 shows this effect.

The presence of multiple screw sets (for large reclaim bunkers) or agitators above the screw (in small-scale applications) will have no effect on the size of the active flow channel that is created. Thus, for unagitated, large-scale installations, the development of stagnant regions of material can be anticipated to develop. The implications of this can range from a fairly benign "loss of live storage volume" to a potentially hazardous "self-heating and ignition" for combustible materials (such as municipal solid waste, biofuels and so on). The development of draw down only over the area of the first pitch is amply demonstrated in Figure 6, where we can see the effect of operating an agitated screw feed in conjunction with carbon black. In common with many types of cohesive powders, carbon black has been consolidated into the non-flowing zone along the screw — leaving only the active flow channel apparent.

Variable pitch spacing

Substantial improvements in the size of the flow channel can be obtained by using (in this instance) a screw feeder that has been designed and constructed to develop an increase in capacity between the pitches along its length. This can be achieved through progressively increasing the pitch spacing from the start of the screw forward, the use of a very wide-diameter shaft that reduces in the direction of feed, or a combination of both techniques. The principle of allowing the development of increased capacity along the screw means that there is transport capacity available under the whole outlet area (Figure 7). For a vessel that has inherent funnel flow behavior, this modification allows the development of the largest possible flow-channel area above the screw. This may be adequate to improve flow reliability, but it will definitely deliver a degree of improvement in screw-delivery consistency (by virtue of the larger flow-channel volume acting on the screw).

It should be noted that the preceding narrative relates to parallel-diameter screws. On paper, a simpler route to attaining increased capacity would seem to be to use a standard constant-pitch screw and progressively increase the outside diameter in the direction of feed. A calculation of pitch volumes would show that an increase in capacity has been achieved, but functionally, this type of screw would not be recommended for bulk solids other than those that are free-flowing, non-time-dependent and those for which the vessel is drained down to empty on a regular basis (a requirement of best practice common to the operation of conventional funnel-flow vessels where risks associated with long-term resident material exist). An issue arising from the use of tapered screws is presented for less than free-flowing bulk solids, whereby they may bridge or arch over the narrow start of the screw. It is possible that, for some materials, active flow cannot occur until further along the development of the screw diameter (which may be as much as one third to one half of the way along the length of the screw). Allied to the flow-channel diameter restriction imposed by the screw diameter is the shape of the trough in which the screw sits. The trough casing will follow a clearance along the screw, which means that in order to interface with a rectangular vessel outlet, the profile will progress from fully developed at the exit from the vessel to a pronounced "V" profile at the narrow diameter.

This V-shaped trough profile imposes another aspect of flow impediment by virtue of material being supported into the vessel from the flanks of the trough. Screws cannot draw material into their sides (hence material retention onto the flanks during discharge). This is a potential problem not just for tapered screw feeders, but also for parallel screw feeders (which are also invariably interfaced to vessels using V-shaped trough profiles).

Holistic view

Much of this discussion has focused on screw feeders, but the same principles for developing increased capacity over the outlet area apply equally to belts, vibratory trays, drag links, rotary valves and so on

Reliability of flow during the operation of storage vessels cannot be decoupled from the influence of vessel geometry and the characteristics of the feeder. In many cases, attempts at addressing flow problems or retention issues in vessels by installing discharge aids of various types have varying degrees of success. For many plants where bulk-solids handling is problematic, a holistic view of the problem is seldom developed. The consequence is that substantial resources are misapplied because the plant fails to consider the interaction of the vessel and feeder as a single entity that should be designed or specified to work together, rather than being brought together as the result of "catalog engineering." ■

Edited by Scott Jenkins

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Inside

BEUMER Group develops digital product for enhanced customer service: the BEUMER Smart Glasses

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Machine malfunctions and standstills that are not eliminated as fast as possible may become expensive for manufacturing companies. **BEUMER Group** developed the BEUMER Smart Glasses as a pioneering product that supports users quickly and easily. The BEUMER Customer Support technicians use them to take a virtual look over the shoulder of the customer's service technician to solve the problem together. This digital solution reduces travel times and costs.

"With the BEUMER Smart Glasses, our customers can get in live contact with our service experts anywhere and at any time," promises Christopher Kirsch, Managing Director of BG.evolution. With this spin-off at the university location of Dortmund, the company brings digital innovation from outside into the company. In other words: "We are working on a customer problem with the support of start-ups to develop 'Minimum Viable Products'. These are minimally equipped prototypes whose market potential and customer acceptance we put to the acid test," explains Kirsch. This makes it easier for the BEUMER Group to decide quickly whether a new technology makes sense to develop into a finished product - such as the BEUMER Smart Glasses.

The customer-employee at the machine puts on the data-glasses and starts the BEUMER Support app via voice command. The employee transmits a service number and a pin code to the hotline, and the connection with image and sound is established. The BEUMER technician receives the same image as the customer. The technician can directly give instructions and display all relevant information in the field of vision. The employee has both hands free to follow the instructions of the expert and carry out the necessary actions. Faults can be solved quickly and precisely - at any time. The BEUMER experts are available around the clock, seven days a week. "Language barriers or the lack of specialised knowledge are no longer relevant for trouble shooting," explains Kirsch. "Together with the user, we can also better validate why the fault occurred based on the recorded images."

"As part of the comprehensive BEUMER Customer Support, users add the BEUMER Smart Glasses as an extension to their monthly or annual hotline service agreement. Together with BG.evolution, the BEUMER Group is currently developing further digital products under the umbrella of "Smart Solutions". "Many of our customers are already showing clear interest in the BEUMER Smart Glasses," explains Christopher Kirsch.

The service technician has all important information displayed in the live image of the camera via the BEUMER Smart Glasses.

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Phoenix Contact Solutions for NOA and predictive maintenance

Unplanned downtimes in a processing plant can cause significant costs. Predictive maintenance is one solution for reducing these costs. A predictive maintenance solution also is designed to prevent unnecessary maintenance interventions by determining when maintenance is truly necessary: At the right time, before something breaks down, or at longer intervals if maintenance is not yet necessary.

Implementing such a solution typically requires data. Status data from the plant which aid the decision making process. In older plants, this requirement often presents technological hurdles. Processing plants such as refineries generally have a planned lifetime of 20 to 30 years. This means that the interfaces are no longer of the latest technological state-of-the-art, often making it difficult to obtain data from the respective plant.

NAMUR has developed a concept for expanding the communications architecture in older plants, thus simplifying communication – or indeed even making it possible for the first time. The NE 175 Recommendation, published at the beginning of August, presents the NAMUR Open Architecture (NOA) concept, which provides an additional, secure communication channel for processing plants.

Data can now be extracted securely from the plant via this so-called NOA channel, in order to, for example, realize predictive maintenance solutions.

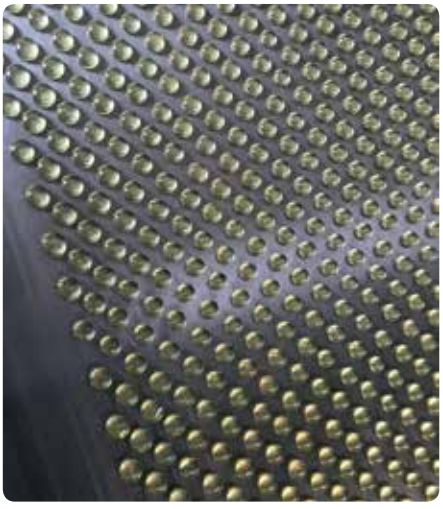
Phoenix Contact provides the perfect hardware for this. The field controllers of the PLCnext range are ideal "NOA Aggregating Servers" as described in NE 175, which can collect data in the field and communicate securely via their integrated OPC-UA servers. PLCnext Technology provides maximum flexibility for a very broad range of applications thanks to the open Linux system.

As the PLCnext controllers are also a component block of the well-established IEC 61131 automation system, sensors that are installed in the plant can be integrated easily via the HART protocol, for example.

The Motor Manager from Phoenix Contact is another option. This is a device that can measure the electrical power drawn, for example, by an agitator motor. This concept uses current transformers which are placed around the supply line of the motor to measure the current. This solution is practically "minimally invasive" in the context of NE 175. The measured data are transmitted to the PLCnext controller via Profinet, where the data are made available to every authorized user in the NOA information model format via the OPC-UA server. The existing control system is not involved in this process, which is the preference of most users.

https://phoe.co/process-industry

Process Equipment – solidification and cooling from one source



As leading full-service supplier **Berndorf Band Group** has established itself as a reliable partner in the areas of steel belt production, engineering of belt systems and worldwide service. Especially, the production of flexible solutions for solidification and cooling systems are an area of expertise of the group.

Following the new market trend the total solution provider, Berndorf Band Group made a transformation from a component manufacturer to a complete system supplier. With the business field "Process Equipment", steel belts, steel belt coolers and feeding devices are combined to build an all-in-one solution for customers particularly in the chemical, petro chemical and sulphur industry.

Benefiting from their long years of experience and expertise in steel belt manufacturing, the Berndorf Band Group produces steel belts that satisfy the demanding requirements during the production of chemicals. Choosing the right belt material is of crucial importance for sectors like the chemical industry. A major role plays here the excellent thermal conductivity and the high corrosion resistance of the steel belt. The chosen premium-grade material ensures an efficient, uniform cooling and solidification of the product in the Berndorf cooling systems.

To guarantee high purity and consistent product quality a good cooling system is needed. Berndorf Band Group offers two types of steel belt coolers, to adapt to the respective product property. A notable function of the single and double steel belt cooler is the possibility of different cooling zones with varying temperatures. Due to that feature the efficiency of the solidification process and the exceptional quality of the end product are ensured.

A variety of Berndorf feeding devices has been developed to meet different process requirements for a wide range of products. The versatile application possibilities enable the production of materials from low to high viscosities and a melting temperature of up to 300 °C as well as the production of pastilles in different sizes.

All together Berndorf's process equipment offers a wide range of flexible solutions which are tailor-made to the demands of the customers, the industry and market trends. Global R&D Centers make Berndorf the only all-in-one supplier who offers customers the optimization of their processes with support from specialists worldwide. From feasibility studies and tests to engineering, design, manufacturing, construction and installation of the plant, customers can rely on the high quality of Berndorf Band Group.

More about the portfolio of Berndorf Band Group:

www.berndorfband-group.com

IPCO: Resin solidification expertise built on decades of experience

As a company whose relationship with the chemical industry extends back to first half of the last century, **IPCO** can offer unparalleled experience in the cooling and solidification of melt products in general, and resins in particular.

These include our flagship Rotoform system, capable of handling an exceptionally wide range of resins including high viscosity products (from 10–40 000 mPas), products with high feed temperatures (up to 300 °C), and those kinds of resins that require particular treatment during cooling.

Today IPCO offers a choice of two granulation systems – flaking and pastillation – both based on the proven performance of our steel belt technology. These efficient and economical processes are suitable for all resin products (pure/modified, unfilled/with filling materials) including:

- Acrylic resin.
- Tall oil resin (colophony).
- Epoxy resin.
- Gum resin.
- Hydrocarbon resin.
- Phenolic resin (Novolake).
- Polyamide resin.
- Polyester resin.
- Silicone resin.
- Modified resins.

In the portfolio, a range of feeding devices to process resins with very different viscosities. All are designed to minimize contact between the product and atmospheric oxygen and to ensure that no air bubbles are added, eliminating any risk of degradation of the resin in the feeding device.

The company's Rotoform system has proved itself over many years to be the ideal process for the granulation of resin products, delivering a superior quality end product regardless of the properties of the material being processed.

It is used for a wide range of resin types – for many it has become the default processing solution – and offers several significant benefits:

- From melt to pastilles in one operation
- Ability to process and solidify sticky and highly viscose resins
- Uniform, hemispherical pastilles – no need for breaking/grinding equipment
- Environmentally friendly production – virtually no exhaust air pollution
- Easy changeover to different products or pastille sizes

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EKATO Industrial photoreactors-turnkey from a single source

Photochemical processes are characterized by high selectivity under mild reaction conditions. They offer access to new realities, unique products and hard-to-copy market positions. However, transferring a photochemical process from the lab to the production scale is a challenge, which requires well founded know-how and experience.

EKATO brings together the very broadly dispersed knowledge existing in the individual specialist areas and offers comprehensive and competent advice, engineering and supply of industrial-sized, stirred photo-reactors, ranging from 10 liters up to 50 m3 filling volume.

Stirred photo-reactors from EKATO ensure a sufficient fluid flow through the irradiated zones inside the reactor. The concept of stirred photo-reactors is ideal for multiphase reactions involving liquids, gases and solids. It combines high productivity and flexibility with the safe operation of immersed light sources.

As UV light sources, ex-certified LED lamps or mercury discharge lamps from Peschl Ultraviolet GmbH with a power range between 5 kW and 60 kW per light source are applied. The lamp system of the reactor gets mounted inside protective quartz tubes which are inserted through the reactor lid and are supported at the reactor wall by a special support structure. EKATO developed material-related expertise and experience in the design of suitable support and sealing elements for quartz immersion tubes.

EKATO consistently supports the customers as a development partner and system integrator on the way from the idea to the photochemical production plant, including the overall responsibility for the design and delivery of the best reactor system for each individual customer process.

www.ekato.com

From the thin film dryer: Powder for plastics production

The basis for the production of plastics are monomers such as 2-acrylamido-2-methylpropane sulfonic acid, also known under the trade name AMPS by The Lubrizol Corporation. This monomer is formed from acrylonitrile and isobutene in the presence of fuming sulfuric acid and water. Finally, unreacted acrylonitrile is separated because acrylonitrile, as an environmentally hazardous, toxic and corrosive substance, must not be released to the environment. After separation, the monomer is a white powder.

Buss-SMS-Canzler thin film dryer under operation.

As current developments show, the last production step can be carried out in thin film dryers from **Buss-SMS-Canzler** particularly effectively and gently. Of special advantage are **the low hold-up in the apparatus, the short residence time of the product** and the **indirect drying without feeding gas** into the dryer. Thus, even **difficult drying tasks with problematical substances** can be accomplished under vacuum. Thus, even difficult drying tasks with problematic substances can be realized under vacuum.

www.sms-vt.com

Evaporators in skid design

In May 2020 **GEA** received the second order for an evaporation plant for the treatment of silver nitrate from the production of omega-3 fatty acids from fish oil from KD Pharma Group. The first plant was successfully commissioned in autumn 2019 in Bexbach, Germany. There, high-quality omega-3 fatty acids are extracted from fish oil, which are used in the food supplement and food industry. In this special process a solution with approx. 11% dry matter (DM) of dissolved silver nitrate is concentrated to approx. 50% DM in the GEA falling film evaporation plant. The concentrated silver nitrate solution can be reused in the process.

The plant with a feed capacity of 1,500 kg/h of silver nitrate solution operates in a vacuum at comparatively low temperatures, so that the concentration takes place gently and the concentrate can be discharged at 60°C. The plant operates in an energy-optimized way with heat recovery. The evaporated vapors are compressed in a mechanical compressor and thus raised to a higher temperature level so that they can be used to heat the plant. Since the customer has little space available, the evaporation plant was designed as a skid. The second plant is almost identical in design to the first one and will start up in spring 2021 - only 9 months after order placement - at the Seal Sands (Middlesbrough) plant in England.

Set-up of the evaporator at KD Pharma in Bexbach, Germany in autumn 2019

GEA evaporators in skid design are completely preassembled. This specification requires a compact arrangement of the individual plant components and a well thought-out piping system. According to its size, the plant can consist of one or several units which do not exceed the transport dimensions of an ordinary semi-trailer. Transporters for extraordinary dimensions are not required. This design can reduce the transport costs and saves time and costs for on-site assembly and commissioning.

About GEA

GEA is one of the largest system suppliers for the food processing industry as well as for a broad range of other industries. The international technology group specializes in machinery, and plants as well as process technology and components. GEA provides sustainable solutions for sophisticated production processes in diverse end-user markets and offers a comprehensive service portfolio.

www.gea.com

Special Control Valves and Actuating Systems

WELLAND & TUXHORN is your reliable partner for Special Control Valves in power plants, industrial plants and chemical/petrochemical plants, such as: HP- and LP- turbine bypass systems, turbine emergency stop valves, turbine control valves, steam conditioning valves, feedwater control valves, minimum flow control valves, cooling water injection valves, boiler start up valves, boiler blow down valves, desuperheater systems, hydraulic and pneumatic actuating systems.

W&T supports the customer to reduce CO_2 by process optimization. The company is distinguished by know-how, persistence, openness to new assignments and the highest developmental and quality standards, which makes the products equally well-known, both domestically and abroad.

Research and development co-operation with scientific and technical institutes creates new theoretical knowledge which is used directly in production, and in optimizing valves currently available.

PRECISION & PROGRESS: First-class in quality and long life

For over 100 years, the highest degrees of precision, quality workmanship and long useful life have defined the product development and production. The robust, impervious and solid construction assures optimal performance and availability.

The consistently high degree of product quality is a result of solid concepts. In addition, a well-thought-out chain of quality assurance measures ensure the long service life of the products. Ongoing supervision of technical drafting designs, manufacturing inspections, strict testing of materials, as well as thorough documentation of the pressure and leakage tests: these are only a few examples of strict quality standards at Welland & Tuxhorn.

The long-standing quality assurance and quality management system, certified according to DIN ISO 9001 and other international guidelines, guarantees highest product quality. W&T is regularly inspected by renowned inspection agencies and is in compliance with all regulations.

TAILOR-MADE SOLUTIONS: Safety for all projects.

The cutting-edge and highly-specialized engineering and production enable W&T to achieve a high level of quality in their fittings. Each and every design concept takes the individual customer's specifications into account.

The newest technologies and a highly-qualified team provide the optimal prerequisites for individual special made-to-order and low-volume production.

W&T service guarantee:

- The high level of quality and functional standards of "Made in Germany" products.
- Consistent focus of the processes toward customer solutions within this specialized market.
- Comprehensive know-how in the fields of steam control and conversion. From valves (including actuators) to switches, to peripheral circuit systems – W&T creates the overview!

www.welland-tuxhorn.de

Advantages of the AMANDUS KAHL Machines for the Chemical Industry

Powdery additives are used in many sectors of the chemical industry. The handling of these sometimes very dusty, often poorly flowing and partly explosive materials is a great challenge for many users. By means of agglomeration by compression of the powdery components, many problems in handling these products can be solved and production processes can be simplified and made safer. Numerous polymer additive mixtures have been compacted and stabilized in this way for many years in order to meet the constantly growing demands of the polymer industry.

AMANDUS KAHL designs and manufactures machines and plants for the processing of powdery products such as inorganic fertilizers, minerals, detergents, detergent additives, master batches and precisely these polymer additives as single components or One-Packs. The focus here is particularly on pelleting presses. By processing polymer additives with AMANDUS KAHL pelleting presses, handling and use of the additives in polymer refinement or compounding can be optimized.

The KAHL machines for use in the chemical industry are characterised by a multitude of design advantages. The large press interior and a product supply by gravity allow high feeding rates without the need for a force feeding device. The KAHL hydraulic system with automatic roller gap monitoring also ensures a safe process control. The low circumferential speed of the pan grinder rollers results in smooth and low-vibration press operation, a long service life of the rollers and roller bearings as well as a low operating noise of approx. 70 dB_A. The tailor-made design of the machines allows a versatile adaptation of the pelleting process to the requirements of the product. Depending on the specific needs, the machines can be manufactured in stainless steel, dust-tight flanged, in dust-ex design or with inerting. The large variety of possible designs of pelleting tools also permits the processing of temperature-sensitive products or those with a high lubricant agent content.

A fast die and tool change enables an almost uninterrupted production run and a high flexibility of the machines when changing products. Remote maintenance and a KAHL service team on site ensure excellent support even after commissioning.

With more than 140 years of experience in the design and manufacture of machines and plants for the processing and pelleting of a wide range of products for different industries, AMANDUS KAHL has acquired a very good international reputation. Machines and plants are characterized by quality “made in Germany”. Are you interested in a machine or plant from AMANDUS KAHL or are you already a KAHL customer? Then visit our website at www.akahl.de or register in our online shop at shop.akahl.de.

www.akahl.de

Optimize calibrations

Putting data to work by optimizing calibration intervals

Achieving the correct balance between too much calibration and too little is a challenge for anyone reliant on critical measurements. Many companies follow a static interval approach and calibrate once a year during scheduled downtimes. This fixed calibration interval selection is a typical illustration of established but outdated rules.

Ideally, calibration intervals should be chosen to reflect an acceptable risk that the measurement error has not drifted outside of an acceptable range. Considering common practice, this is seldom the case. Often calibration intervals are set to one year for the sake of convenience as it aligns well with annual planning cycles. However, calibration intervals should be optimized to find the best trade-off between cost and risk.

Using established existing statistical methods as a base, **Endress+Hauser** has developed an enhanced method for calibration interval optimization. With Calibration Interval Optimization Endress+Hauser has developed a service that delivers more than a calculated result. Significant interval changes are discussed, and all underlying assumptions validated together with the customers. Intervals are then included as one of a number of operational constraints including downtime availability to deliver a fully optimized calibration execution schedule. In the end, the customer benefits from an overall reduction of both cost and risk.

This scientific model has been proven across +22 billion calibrations and considers past calibration results to predict future behavior with the following main results:

- 67% of current calibration intervals could be significantly increased
- only 20% of instruments are set up with an optimal calibration interval
- time operating out of tolerance can be reduce by 46% compared to a static approach

Calibration Interval Optimization uses a proven scientific model to determine intervals between calibrations.

It includes:

- Determination of optimal calibration intervals using innovative methods
- Consultancy provided by metrology experts
- Alignment to, and application of intervals according to operational constraints

The benefits:

- Reduction of calibration costs due to extended calibration intervals
- Reduced out of tolerance risk as calibration intervals are reduced

www.endress.com

Ultrasonic Flow Meters for Additives

Accurate and compact liquid flow meters of **Bronkhorst**'s ES-FLOW Series operate on an innovative measuring principle, using ultrasound in a very small tube. They have been developed to measure low flow rates e.g. of additives, from 4 to 1500 ml/min. A wide range of liquids can be measured independent of fluid density, temperature and viscosity.

Due to the combination of a straight sensor tube with zero dead volume, self-drainability, orbital TIG-welding and hygienic connections, these flow meters can be used for hygienic applications. Wetted parts are made of stainless steel, except for the rubber gaskets at the Tri-Clamp or flange

connections. The exterior design is according to IP66 as well as IP67. For non-hygienic applications, the instruments can also be equipped with compression type fittings.

The user interface is a capacitive touch-screen with a TFT display to operate and readout the instrument. Also, the flow meters feature fieldbus interface options and additional functions such as totalisation and alarms. They can be tuned according to customer requirements using the RS232/ fieldbus interface and free software tools.

The liquid flow meters contain an adaptive PID controller for fast and simple operation of a variety of control options. In additive dosing applications, the flow meters are often combined with miniature gear pumps. This eliminates the need to pressurise the fluid at the inlet side, which would be required for flow meters combined with control valves.

www.bronkhorst.com

Sustainable, energy-efficient and intrinsically safe

Tried and tested chemical pump for extreme challenges

The horizontal, magnetically coupled centrifugal pump $MPCH_{DryRun}$ produced by the pump specialist **Bungartz** is particularly suitable for pumping liquids which are laden with solids. The chemical pump is suitable for all ATEX categories and has proven its worth all over the world for the pumping of hazardous liquids and gas-laden media. It is even used for hot products such as melts without any prefilter. Liquids can be pumped at a temperature of up to 400°C liquids without any external cooling or flushing. This enables a heat barrier to be created between the product room and storage space, thereby minimizing the heat transmission to the bearing mount. The unique design principle is based on a magnetic coupling and the so-called hydrodynamic shaft seal. The Magnetic drive runs permanently dry at a reduced pressure.

The ceramic containment can located between the inner and outer magnet rotor enables eddy current-free magnetic field transmission without any product contact. The advantage: The $MPCH_{DryRun}$ does not require any dry-running protection and can even be operated without liquid. "It also runs when it runs dry", is how Frank Bungartz, (CEO) of the company of the same name, puts it.

Unlike conventional magnetic drive pumps, the shaft is supported by grease-lubricated roll bearings which are extremely low-maintenance. The efficiency of the $MPCH_{DryRun}$ is significantly increased due to the use of ceramic containment cans that are free of eddy currents. The permanently lubricated roll bearings have a proven service life of at least 32,000 hours.

Like all hydrodynamic sealing systems, this chemical pump also operates free of wear. Low life cycle costs also result from low maintenance requirements with high annual pumping runtimes. Not least the long service life makes this intrinsically safe chemical pump a sustainable investment. Reliability and consistency are components of the company philosophy. This is also shown by the availability of wearing and spare parts over several decades.

www.bungartz.de/en/mpch-dryrun.html

Economic Indicators

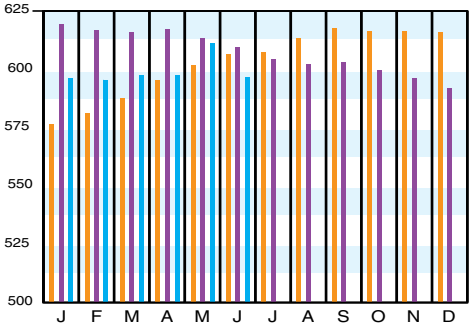
2018 2019 2020

Download the CEPCI two weeks sooner at www.chemengonline.com/pci

CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

(1957–59 = 100)	June '20 Prelim.	May '20 Final	June '19 Final
CE Index	591.1	593.5	609.5
Equipment	715.7	720.3	743.2
Heat exchangers & tanks	610.6	616.1	659.7
Process machinery	719.0	721.1	727.0
Pipe, valves & fittings	934.2	942.2	955.7
Process instruments	411.8	409.6	416.4
Pumps & compressors	1084.1	1086.3	1068.5
Electrical equipment	561.3	561.1	557.7
Structural supports & misc.	764.7	774.0	810.9
Construction labor	335.4	333.8	335.4
Buildings	591.3	587.4	595.8
Engineering & supervision	313.0	312.6	313.8

Annual Index:
2012 = 584.6
2013 = 567.3
2014 = 576.1
2015 = 556.8
2016 = 541.7
2017 = 567.5
2018 = 603.1
2019 = 607.5

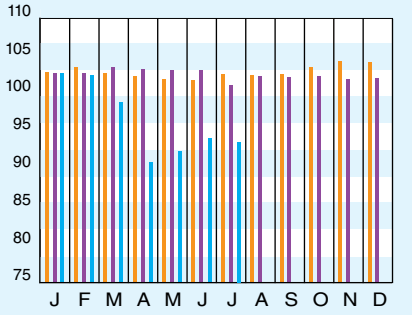


Starting in April 2007, several data series for labor and compressors were converted to accommodate series IDs discontinued by the U.S. Bureau of Labor Statistics (BLS). Starting in March 2018, the data series for chemical industry special machinery was replaced because the series was discontinued by BLS (see *Chem. Eng.*, April 2018, p. 76–77.)

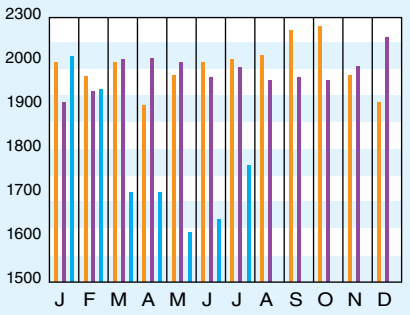
CURRENT BUSINESS INDICATORS

	LATEST	PREVIOUS	YEAR AGO
CPI output index (2012 = 100)	Jul. '20 = 93.3	Jun. '20 = 92.2	May '20 = 89.1	Jul. '19 = 101.5
CPI value of output, $ billions	Jun. '20 = 1,761.1	May '20 = 1,637.2	Apr. '20 = 1,587.3	Jun. '19 = 2,016.7
CPI operating rate, %	Jul. '20 = 69.4	Jun. '20 = 68.6	May '20 = 66.3	Jul. '19 = 75.7
Producer prices, industrial chemicals (1982 = 100)	Jul. '20 = 217.6	Jun. '20 = 211.9	May '20 = 203.1	Jul. '19 = 249.3
Industrial Production in Manufacturing (2012 =100)*	Jul. '20 = 96.5	Jun. '20 = 93.4	May '20 = 87.0	Jul. '19 = 104.6
Hourly earnings index, chemical & allied products (1992 = 100)	Jul. '20 = 191.0	Jun. '20 = 190.7	May '20 = 192.2	Jul. '19 = 184.9
Productivity index, chemicals & allied products (1992 = 100)	Jul. '20 = 100.8	Jun. '20 = 98.9	May '20 = 99.0	Jul. '19 = 96.5

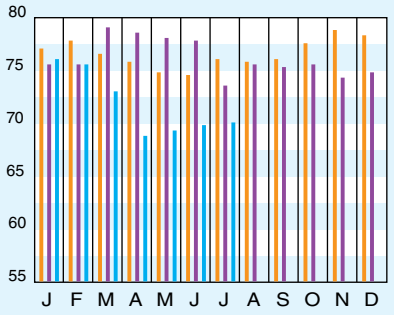
CPI OUTPUT INDEX (2000 = 100)†



CPI OUTPUT VALUE ($ BILLIONS)



CPI OPERATING RATE (%)



*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
†For the current month's CPI output index values, the base year was changed from 2000 to 2012
Current business indicators provided by Global Insight, Inc., Lexington, Mass.

CURRENT TRENDS

The preliminary value for the *CE* Plant Cost Index (CEPCI; top) for June 2020 (the most recent available) decreased compared to the previous month's value, following a similar decline in April and May. The lower value for the Equipment subindex in June offset rises in the other three major subindices (Buildings; Construction Labor; and Engineering & Supervision), giving rise to a lower value for the overall CEPCI. The current CEPCI value sits at 3.0% lower than the corresponding value from June of last year. Meanwhile, the Current Business Indicators (CBI; middle) showed an increase in both the CPI output index and the CPI operating rate for July and the CPI value of output for June.